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TESTS

FOR

GOLD AND SILVER IN SHALES FROM WESTERN KANSAS

BY

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TESTS FOR GOLD AND SILVER IN SHALES FROM WESTERN KANSAS.

By WALDEMAR LINDGREN.

INTRODUCTION.

The assertion that certain clay shales of western Kansas contain gold and silver dates back about seven years. In 1895 a company of men, among them a certain H. H. Artz, sunk a shaft near Smoky Hill River, in Trego County, prospecting for zinc. It is stated that some indications of this metal were found, but of more importance was the announcement that the soft clay shales encountered contained a notable percentage of gold. It soon became known that the same clay shales extended through a large part of Ellis County and were especially well exposed in the bluffs along Smoky Hill River in the southern part of that county. A great number of assays of these shales were made by different persons, and a large percentage of the samples was said to contain gold and silver. The asserted amounts vary considerably. Dr. J. T. Lovewell, of Topeka, in a paper read before the Kansas Academy of Science,[a] stated that he had made many hundreds of assays and supposed that the clay had average values of \$2 to \$3 per ton in gold and silver, the latter metal always accompanying the gold. One series of 100 assays gave an average of more than \$10 per ton. Dr. Ernst Fahrig, of Philadelphia,[b] obtained from actual mill runs in an experimental plant an average of \$2.80 per ton. One of these runs yielded 2.6 ounces silver and \$1.36 gold per ton, and another of them gave an aggregate value of \$6.75 per ton. The Kansas Pioneer Gold Shale Company, advertising their stock in the principal papers of St. Louis, Chicago, and New York, state the value as \$8 to \$10 per ton, and compute the wealth contained in one acre of shales to be \$5,250,000. Others, among them Prof. E. Haworth, of the Kansas State University, have denied that the shales contain gold in notable quantities.[c]

The statements of tenor obtained by assays are usually accompanied by the explanation that the values are extremely irregular, different assays from the same carefully mixed pulp giving widely differing results.

[a] Topeka Semiweekly Capital, January 3, 1902.

[b] Kansas Daily Capital, Topeka, May 3, 1902.

[c] Kansas Semiweekly Capital, Topeka, June 6, 1902. Mineral Resources of Kansas for 1898, Lawrence, Kans., 1899.

It was not long before mills were erected to extract the values from the clay shale. In 1900 a company was formed and erected a mill on Smoky Hill River, 14 miles west-southwest of Hays. Some kind of a chloridizing process was to be used, but no run was ever made, the superintendent and owner of the process, W. F. Miller, absenting himself unexpectedly before actual work had begun. In 1901 a smaller experimental mill was built near the works just mentioned by Mr. A. G. Gage, who used a variation of the cyanide process, and claimed to have extracted some gold during a series of short runs. In the spring of 1902 the Kansas Pioneer Gold Shale Company built a mill using the same process and supposed to handle 100 tons per day. This mill, which is located 11 miles southwest of Hays, on Smoky Hill River, had just started crushing and leaching in May, 1902. Finally, during the same month, a company called the Fahrig Mining and Milling Company was organized in Topeka for the purpose of constructing and operating a 100-ton mill on Smoky Hill River. The Fahrig process consists in treating the ore with a salt of unrevealed composition and in precipitating the gold and silver by electrolytic methods.

FIELD WORK.

The investigation of the Kansas shale deposits was undertaken by the United States Geological Survey in May, 1902. The actual work in the field occupied eight days, from May 12 to May 20, and was carried on from Hays as a base.

LOCATION.

Although attention was first drawn to the shales in question through prospecting work in Trego County, all the later developments have taken place in Ellis County, adjoining Trego County on the east. Ellis is one of the west-central counties of Kansas. Its county seat, Hays, is located on the line of the Union Pacific Railroad, 272 miles west of Kansas City. Although near the western limit of the "rain belt," the county produces much wheat and supports a numerous and well-to-do farming population.

TOPOGRAPHIC FEATURES AND DRAINAGE.

The region is drained by Smoky Hill River, which has its headwaters in eastern Colorado and flows through the southern part of Trego and Ellis counties almost due east to its junction with the Saline River. In Ellis County Saline River flows parallel to and 25 miles north of Smoky Hill River. Big Creek traverses Ellis County diagonally, flowing southeasterly to its junction with Smoky Hill River. As may be expected of a stream heading in an arid country, Smoky Hill River sometimes runs dry. After heavy rains it rises rapidly and is often unfordable.

The general relief is that of a rolling, gently undulating country,

through which the rivers have cut well-defined though not very deep trenches. The elevation at Hays is 2,000 feet. Along Smoky Hill River south of Hays elevations range from 1,900 to 2,000 feet. Smooth, grassy hills rise between Big Creek and Smoky Hill River to 2,200 and 2,300 feet, and to somewhat less elevation between Big Creek and the Saline. East of Hays still more gentle outlines prevail, the divide rising little more than 100 feet above the main streams. The highest elevations, 2,400 feet, are in the rough hills south of Smoky Hill River, about 20 miles west-southwest of Hays.

Smoky Hill River flows in a sandy bed rarely more than a few hundred feet in width. The gentle curves of the stream are marked by steep bluffs, 20 to 80 feet high, on the convex side and moderate slopes on the opposite, concave, side. These bluffs are due to the lateral cutting of the banks by the river.

This part of Kansas is mapped by the United States Geological Survey on a scale of 2 miles to the inch and with a contour interval of 20 feet; the Hays and Ellis quadrangles embrace all points referred to in this paper.

GEOLOGICAL FEATURES.

The geology of this part of Kansas is described in a general way in Volume II of the Report of the University Geological Survey of Kansas. The rocks exposed are sedimentary and of Cretaceous age, excepting the sands and gravels along the river, which, of course, are of much later (Pleistocene) age. The two great divisions of the Cretaceous, the Benton and the Niobrara, cover the whole area. The beds of shale and lime lie nearly horizontal but have a slight northeasterly dip.

CRETACEOUS ROCKS.

Beginning from the top, that part of the Cretaceous column with which we are here concerned is subdivided as follows:[a]

Section of Cretaceous rocks in western Kansas.

			Feet.
Niobrara group		Smoky Hill chalk	300
		Fort Hays limestone	50
		Septaria horizon.	
Benton group	Upper	Blue Hill shale	100
		Ostrea shales	150
		Fencepost limestone	1
	Lower	Inoceramus horizon	5
		Flagstone	10
		Lincoln marble	15
		Bituminous shale	30
		Total	661

[a] The divisions here used follow the description by Prof. E. Haworth, Geol. Surv. Kansas, Vol. II, pp. 215-221.

Niobrara group.—The upper member of this group, the Smoky Hill chalk, does not cover notable areas in Ellis County. The Fort Hays limestone, on the contrary, is exposed on the hills south of Hays and also to some extent on the ridge north of that town. The thickness is not over 50 feet. The rock is a yellowish limestone, easily dressed and locally used as building stone. It appears again south of Smoky Hill River, capping the shale in the roughly eroded area 20 miles west-southwest of Hays.

Just below the Fort Hays limestone is a well-marked horizon, in which the shales contain large calcareous concretions (septaria), often large and containing abundant veins and crystallized masses of calcite of different colors ranging from white to dark brown.

Benton group.—A great thickness (250 feet) of shales underlies the Fort Hays limestone. The upper 100 feet are called the Blue Hill shales and are fissile light-gray to dark-gray shales without fossils and containing only small amounts of pyrite and organic matter. These are exposed in the hills west and northeast of Hays. They also outcrop below the same limestone on the south side of Smoky Hill River, 18 miles west-southwest of Hays, and extend far up into the adjoining Trego County along the river. Samples 3, 18, and 19 are from this horizon. The shales forming the bed rock at Hays probably belong in the lower part of this division. Several deep wells sunk 4 and 5 miles east and east-northeast of Hays penetrated nothing but shales to a depth of 200 to 360 feet.

The lower division, called the Ostrea shales, is 150 feet thick and covers a large area, especially along Smoky Hill River, from some point in Trego County down to a point south or a little southeasterly of Hays. It is a dark-gray calcareous shale, containing a little pyrite, finely divided and also sometimes in concretions. It also contains an abundance of fossil shells, largely of *Ostrea congesta;* sharks' teeth are also often found. Narrow bands of light-gray or yellowish-gray limestone part the shale at intervals of from 5 to 20 feet. Almost the only good exposures are found along the river banks, on either side, according to the curves of the river. Here the bluffs are from 20 to 60 feet high, and if the rock is not fresh on the surface it takes but little work to obtain unaltered material. Near the top of the bluffs the shales are whitish and decomposed and usually covered with Pleistocene sands.

The shales are almost black when somewhat moist, but have a dark-gray color when dry. They generally appear mottled by minute whitish specks in a darker predominating mass. The weathered outcrops are soft and disintegrate into a clayey soil, breaking up into small flat fragments. When fresh the shale is quite compact, though breaking easily into large flat fragments 2 to 4 inches thick. While the upper Blue Hill shales are poor in calcite, the Ostrea shales effervesce readily with acids. When washed in a miner's pan,

the heavy residue consists of calcite grains, a few fragments of quartz, and some scant, well-rounded granules of black iron ores; besides there is always a little extremely fine-grained pyrite. No colors of gold could be detected. Samples 1, 2, and 4 to 14 (see pages 10–12) are from the Ostrea shales.

The Lower Benton group contains much more limestone than the upper division. It consists of about 70 feet of alternating shales and limestone, as indicated in the above table. It is exposed in the eastern part of Ellis County, though the identification of its various members is not easy during a rapid traverse of the country. The 50-foot bluffs of shale covered by limestone, on the north bank of Smoky Hill River, 3 miles west of Pfeifer and also at Falkenstein's farm on the south bank, about the same distance from the town mentioned, are believed to belong in this horizon. Samples 15, 16, and 17 are from this horizon. The Ostrea shales on Smoky Hill River at a point 14 miles west-southwest of Hays are 250 feet below the Fort Hays limestone, and must consequently be near the bottom of the Upper Benton. The vertical distance from here to the Dakota sandstones below can hardly be more than 100 feet.

PLEISTOCENE ROCKS.

To this most recent time division belong the sands and fine gravels along the bottoms of Smoky Hill River and also covering the low shale bluffs which follow the stream. The material of this terrane is chiefly quartzose and the grains are remarkably well rounded. By washing the material in a miner's pan a heavy residue of black sand, probably both magnetite and ilmenite, is obtained. These grains also are extremely well rounded. Besides, the sand contains abundant grains of garnet and some epidote; fragments of topaz are also said to occur. A number of pans of this sand was washed near Copeland's road crossing, and in one a very minute color of gold was obtained.

SAMPLING AND ASSAYING.

SAMPLING.

The principal gold-bearing stratum is supposed to be the Benton group, including the Ostrea shales and the Blue Hill shales. It is stated that these rocks over practically the whole of the areas in which they occur contain more or less gold and silver, though the metals may be rather irregularly distributed. Samples showing value are claimed to have been obtained in Trego County along Smoky Hill River as far westward as the Benton shales extend, all along Smoky Hill River in Ellis County, and also in Rush County, adjoining on the south.

It is claimed that values have also been found in samples collected near Hays; for instance, in the shales underlying the Fort Hays

limestone 4 miles west of the town, and also in samples collected along Saline River, along which Fort Benton shales are also said to outcrop. All the mills, however, are located on Smoky Hill River southwest of Hays, and from this vicinity have also been taken the by far largest number of assayed samples.

In order to arrive at a reliable conclusion regarding the contents of these shales in precious metals, the samples described below were carefully taken. The method used included, first, the clearing of a convenient exposure to a required depth so as to obtain fresh material. Along the river bluffs the shales are very little altered and fresh rock is comparatively easily found. The required thickness of shale being exposed (usually amounting to from 2 to 4 feet), a sample of from 20 to 30 pounds was broken down on a square of canvas; this material was then reduced to pieces about the size of a walnut, or smaller, and the whole amount was quartered down twice to a weight of from 3 to 5 pounds. It was then put into quart jars and the same securely sealed. The following samples were taken:

Samples collected for assay.

No.	Locality.	Character of material.
1	South side of Smoky Hill River, 3½ miles east of the line dividing Ellis and Trego counties. Small quarry located behind Miller's mill, 20 feet above the river. Exposure 25 feet high. This sample represents the average of 3 feet from floor of quarry up to the lower band of limestone.	Black shale containing some pyrite and divided by two narrow bands of gray limestone.
2	Same as No. 1. This sample represents 3 feet of shale between the two layers of limestone. Above the upper limestone band the shales appear decomposed by surface action.	Dark-gray shale with fossils and some concretions of pyrite.
3	South side of Smoky Hill River, 3½ miles northeast of the southwest corner of Ellis County, and about 2½ miles south of Miller's mill. The horizon is in the Blue Hill shales just below the Fort Hays limestone. The elevation is about 2,250 feet. This sample represents an average thickness of 2 feet.	Thinly laminated gray clay shale with no fossils and but little organic matter.
4	Mouth of gulch emptying into Smoky Hill River from the south, 3½ miles west of the Ellis-Trego county line. This locality is about 200 feet west of Gage's experimental mill. The bluff is here 30 feet high and consists of dark-gray shale divided by two narrow partings of gray lime. The sample represents 3 feet of shales 2 feet above the bed of the gulch.	Dark-gray Ostrea shale with fossils and a little pyrite.

Samples collected for assay—Continued.

No.	Locality.	Character of material.
5	Same as No. 4. 500 feet east of Gage's experimental mill. From small pit in shales at the river level, which showed indication of having been recently blasted. Material for experimental work in Topeka was reported to have been taken from this locality. The exposure showed 6 feet of shale covered by 10 inches of gray lime; above this 6 feet of shale. The sample covered 3 feet of the lower shale.	Fossiliferous Ostrea shales of dark-gray color containing a little pyrite.
6	Same as Nos. 4 and 5. 650 feet east of Gage's experimental mill at base of 30-foot bluff, the upper part more or less decomposed. This sample is an average of 2 feet close to river level.	Dark-gray fossiliferous shale with a little pyrite.
7	Same as No. 6. Average of 3 feet, from 5 to 8 feet above river level.	Dark-gray fossiliferous shale with a little pyrite.
8	South bank of Smoky Hill River, 11 miles southwest of Hays and 1 mile west of Copeland's crossing, in quarry from which material was being extracted for reduction in the Pioneer Company's new mill. The place is less than 100 feet distant from the mill. The bluff is here approximately 30 feet high, the upper 6 feet consisting of well-washed Pleistocene sand. Below this 4 to 6 feet of decomposed shale, below which the quarry has exposed fresh material. The sample is an average of the shale from 8 up to 10 feet above the river.	Dark-gray clay shale, fossiliferous and containing a little pyrite.
9	Same as No. 8. The sample is an average of 2 feet, from 10 to 12 feet above the river level.	Dark-gray fossiliferous shale containing a little pyrite.
10	About 150 feet east of the Pioneer Company's mill. The bluff is here 18 feet high and consists of shale with two or three narrow bands of harder limestone. The sample represents an average of 3 feet, from 5 to 8 feet above the river.	Dark-gray fossiliferous shale.
11	South bank of Smoky Hill River, one-fourth mile west of the Pioneer Company's mill. Twenty-five-foot bank of shale covered by 6 feet of sand and gravel. The sample was taken from blasted cut 2 feet above river level, from shale averaging 2 feet in thickness.	Dark-gray fossiliferous shale with a little iron pyrites.

Samples collected for assay—Continued.

No.	Locality.	Character of material.
12	North bank of Smoky Hill River, 10¼ miles southwest of Hays and 300 feet east of Copeland's road crossing. The shale bluff is 30 feet high and contains four smaller bands of dark-gray lime. The sample was taken 4 feet across just above the river.	Dark-gray fossiliferous shale.
13	North bank of Smoky Hill River, 800 feet west of Copeland's road crossing. Shaft 40 feet deep, 15 feet above the river. Filled with water. The sample was carefully picked from east side of dump.	Dark-gray fossiliferous shale.
14	Same as No. 13. Sample picked from west side of dump.	Dark-gray fossiliferous shale.
15	Fifteen miles south-southeast of Hays, in Rush County, 3½ miles west-southwest of the town of Pfeifer. South side of Smoky Hill River, 1 mile south of sharp bend; Baskel's farm on Shelter Creek; bluff opposite house on west side of creek, consisting of 35 feet of thin-bedded shale capped by 12 feet of yellowish limestone.	Dark-gray clay shale with some fossils.
16	Fourteen miles south-southeast of Hays, in Rush County, near boundary line of Ellis, 4 miles west-southwest of Pfeifer. South side of Smoky Hill River at Falkenstein's farm. Bluff 15 feet high from river level of shale with several indistinct limy layers.	Nodules of partly decomposed iron pyrites in shale.
17	Same as No. 16. Average of 2 feet of shale about 8 feet above river level.	Dark-gray shale without much carbonaceous substance.
18	Four and one-half miles west-northwest of Hays and one-fourth mile south of railroad, on farm of J. C. West. Bluff of 50 feet of Blue Hill shale without lime partings, overlain by 20 feet of Fort Hays limestone. Average of 2½ feet near top of shale, 6 feet below limestone.	Dark-gray clay shale without fossils, and with little carbonaceous material.
19	Same as No. 18. Average of 3 feet of shale at foot of bluff.	Dark-gray clay shale.

PREPARATION OF SAMPLES FOR ASSAYING.

The 19 samples described above were sent to Washington, D. C., and further examined. The shale in each lot was crushed, carefully mixed, and quartered down until the last half of the sample amounted to one-half to three-fourths pound. This quantity was finally ground

and sieved through an 80-mesh screen. From this ground material the assays were made.

METHODS OF ASSAY.

The fire assay, as well known, consists in smelting in crucible or scorifier with litharge or lead. The lead absorbs the gold and silver contained in the ore, and this gold and silver remains behind when the lead is driven off by a process of oxidation. For small and moderate amounts of the precious metals this is the most accurate method known, and in skillful hands always gives reliable results. The claim that "the fire assay will not bring out the values" is well known and reiterated to weariness, especially in districts where higher values are desired than nature put in the ores. True enough, the fire assay, like any other analytical operation, requires intelligent care and suitable ingredients. Where there are large amounts of copper, zinc, tellurium, and similar elements in the ore, this assay needs particular attention in order to prevent losses. As in every other quantitative analytical process, there are sources of error in the fire assay. A very small quantity of gold and silver may be lost in the slag in the first smelting. This is generally inappreciable. But in cupelling the lead button there is always a certain loss of silver by absorption by the cupel, much less by volatilization. This loss may amount to several per cent in case of very poor ores and small silver beads, but is then generally practically negligible. The loss of gold during cupellation is ordinarily very much smaller than that of silver, and practically nil. One often hears assertions that the proper values are not brought out by this assay because of the extremely fine distribution of the gold. This is absurd, because the chemical reaction, i. e., the absorption of gold and silver by the lead, takes place practically independent of the mechanical state of the precious metals. If anything, a fine division would be more favorable to their absorption by the lead. In the same category may be put the assertion that the gold in these shales is carried away in the fumes from the crucible.

When one considers that the very minute particles in a low-grade but paying ore, even after fine crushing, are likely to be securely locked up in grains of quartz or other refractory material, it becomes clear that the extraction of gold by chlorine, bromine, or potassium cyanide, which have little effect on these inclosing shells, must be less effective than a fusion. In a fusion with proper fluxes these shells are completely disintegrated, and the molten lead dissolves the precious metal almost entirely. The fire assay is, in fact, used in all cyanide and chlorination works to test ores and tailings.

This statement regarding the wet process also holds good for analytical work. Only in case the ores contain large quantities of gold or silver do the wet methods offer any advantage over fusion and cupellation. Electrolytic quantitative tests of gold and silver are

known, but rarely used,[a] offering no advantage over other assays and requiring as much preliminary work in the elimination of other metals as do wet tests by precipitation of the gold by hydrogen sulphide, zinc, oxalic acid, or other means.

The accuracy of the fire assay varies, of course, with the quantity and character of the material, the purity of the reagents, and the skill of the assayer. Dr. W. F. Hillebrand, operating on Leadville rocks, gives 0.005 ounce per ton as the limit of accuracy for silver assays when 4 assay tons of material are used and extremely careful and painstaking work is done.[b] Using 2 assay tons in ordinary work, one ought to easily determine quantities of 0.05 ounce of silver ton, and 0.005 ounce, or 10 cents, per ton of gold.

RESULTS OF ASSAYS.

The nineteen samples were first assayed by myself in the laboratory of the Survey. The general proportions of the charge were as follows: One A. T.[c] shale, 2 A. T. litharge (contents of silver, 0.005 ounce per ton), 2 A. T. soda, one-half A. T. borax. A layer of litharge was spread over the mixed charge and a layer of salt above this. Samples 1 to 8, inclusive, were assayed with a charge of 2 A. T. shale, and the rest of the fluxes were in the proportion given above. For the remaining numbers 1 A. T. was used. Samples 1, 3, 17, 18, and 19 were assayed without addition of nitrate of soda, and in case the lead button was too large it was scorified down to suitable size. In the remainder of the samples which contained much carbon, niter was added in varying proportions to obtain a convenient button.

For the purpose of collecting the gold, in case no silver was present in the shale, 1.5 to 3 mg. of chemically pure silver was added to each assay, excepting Nos. 1 and 2. This was recovered, minus the minute losses chiefly caused by the absorption of the cupels. No gold was found in any of the samples, though in some of them minute black specks remained after parting the silver buttons. Some of these disappeared on ignition, while others remained, but upon examination with the lens failed to show the luster and color of gold.

The same samples were then assayed in the laboratory of the Survey, by Dr. E. T. Allen, who reports as follows:

> I have examined nineteen samples of shale from western Kansas, collected by Mr. Lindgren, and find no gold in any of them.
>
> The samples were assayed in the crucible with about 1 part soda and 2 parts of litharge to 1 part of the ore, and, since most of the shales contained considerable carbonate of calcium, from one-half to 2 parts of borax and some powdered glass were added to make the fusion thinly fluid. Niter was put in to oxidize the excess of carbonaceous matter in all but Nos. 15, 18, and 19. Two A. T. of each sample

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[a] A. Classen, Ausgewaehlte Methoden der analytischen Chemie, Braunschweig, 1901, pp. 3, 245, and 254.

[b] Mon. U. S. Geol. Survey, Vol. XII, p. 595.

[c] A. T. = Assay ton = 29.166 grams.

were taken except Nos. 7, 8, 10, and 12, where only one A. T. was used. Two or 3 mg. of gold-free silver were added to each crucible charge to collect the gold in case the quantity of silver in the shale should prove insufficient. This silver was recovered after cupellation, minus a very small and nearly constant loss, which is always caused by absorption by the cupels, volatilization, etc. When the beads were parted the majority dissolved without residue. In several there remained one or two extremely minute, unweighable black specks. These either disappeared on ignition or else failed to develop the color and luster of gold, though they were examined carefully with a good lens.

In the previous work the added silver might easily have masked the presence of small fractions of an ounce of that metal per ton in the shale. Consequently, a third series of assays of the same samples was undertaken jointly by Dr. E. T. Allen and myself, in order to ascertain whether small quantities of silver were present. The laboratory and all utensils employed were kept scrupulously clean, and we do not believe that there was any possibility of the introduction of gold or silver into the samples except from the litharge. The latter was assayed in duplicate, using 10 A. T. in each charge, with the following result:

Assay of litharge.

Number.	Silver.	Gold.
	Ounce per ton.	
1	0.005	Distinct trace in 10 A. T.
2	0.005	Doubtful trace in 10 A. T.

The particles remaining after parting were carefully examined by a microscope of high power.

The charges for the assays were in the main similar to those indicated above. Two A. T. shale were used in all of the assays except in 11, 15, 16, 17, 18, and 19, in which 1 A. T. was taken. The assay of No. 3 failed and no more material was available. About 1½ parts of litharge to 1 part of shale were used. The cupellation was undertaken with particular care to guard as much as possible against losses from absorption and volatilization. In the cases where weighable buttons were obtained the quantity of silver due to the litharge was subtracted, and the figures given in the following table thus indicate the true amount of silver contained in the shale.

Of six samples marked "repeated" in the table duplicate assays were made. In the duplicates the niter method was avoided and a charge was made as follows: One A. T. ore, 3 A. T. litharge, 2 A. T. soda, one-half A. T. borax. Nos. 14 and 16 were roasted and some argol was added to the charge.

The parting was effected in small glazed porcelain capsules and with very exceptional care. The residue after parting and annealing was examined by a petrographic microscope. In No. 5 we obtained

from 2 A. T. two flakes of gold weighing together 0.01 mg., equaling 0.005 ounce per ton, or a value of 10 cents per ton. In No. 13 several very minute, unweighable flakes of gold were discovered by using high magnifying powers; they could not be recognized by an ordinary lens.

In nearly all of the samples after parting and ignition almost microscopic, unweighable black specks were found. It was determined to subject these to more detailed examination. Under high magnifying power these specks appeared as angular, irregular masses having a dark-gray or black color and submetallic to metallic luster. A few of them were loose aggregates of the same substance with occasional glints of silvery or yellowish luster, which might possibly arise from included particles of gold. The appearance under the microscope is that of graphite. Besides this substance only a few particles of oxide of iron were noted in the residue. A number of the black specks collected were then subjected to the following chemical tests: First, evaporated with aqua regia to dryness, the specks were still visible and seemed unattacked. We next tried burning in a stream of oxygen. The operation was difficult on account of the minute size of the particles, but in two separate trials the specks disappeared upon being treated in a current of that gas. In conclusion, we assert that these dark particles are neither gold nor platinum, though we suspect that in many cases they have been reported as traces of gold. We believe it most probable that these particles are graphitic carbon, contained in the silver. It will probably be objected that carbon could not without change pass through the oxidizing operation of cupellation. Be this as it may, the quantity of carbon obtained was certainly extremely small, and it is a known fact that silver has a decided tendency to unite with carbon under some conditions, as shown by Gmelin-Kraut.[a]

Content of gold and silver in samples of shale.

Number.	Silver.[b]	Gold.	Total value.
	Ounce per ton.	*Ounce per ton.*	*Per ton.*
1	None.	None.	....
2	0.007	None.	$0.004
4	None.	None.	....
5	0.017	0.005	.110
6	0.007	None.	.004
7	0.022	None.	.013
8	0.037	None.	.022
9	0.097	None.	.060

[a] Handbuch der Chemie, Vol. III, pt 2.

[b] Although the quantities of silver have been given to the third decimal, as calculated from the weights of the beads, it must be understood that quantities below 0.01 or 0.02 ounce per ton are very doubtful under these conditions.

Content of gold and silver in samples of shale—Continued.

Number.	Silver.	Gold.	Total value.
	Ounce per ton.	*Ounce per ton.*	*Per ton.*
10	Probably none.	None.	....
10	None.	None.	....
11	0.045	None.	$0.027
11	0.030	None.	.018
12	Probably none.	None.	....
12	0.030	None.	.018
13	0.087	Microscopic trace.	.052
13	None.	None.	....
14	0.072	None.	.043
14	None.	None.	....
15	0.085	None.	.051
16	0.037	None.	.022
16	None.	None.	....
17	0.095	None.	.057
18	Probably none.	None.	....
19	Probably none.	None.	....

For further confirmation the samples of most importance—that is, those from the banks of Smoky Hill River, in the vicinity of the mills—were sent to Mr. George E. Roberts, the Director of the Mint, who kindly had them assayed. Nos. 1, 2, 4, 5, 6, 7, and 8 were assayed by Mr. W. F. Bowen, assayer of the mint bureau, and Nos. 9, 10, 11, 12, 13, 14, and 16 were assayed by Mr. Jacob B. Eckfeldt, assayer of the mint in Philadelphia.

Mr. Bowen states that he used 1 A. T. ore to 1 A. T. litharge with necessary fluxes, and that a little niter was added. His results are as follows:

Assays of samples by W. F. Bowen.

Number.	Silver.	Gold.	Total value.[a]
	Oz. per ton.	*Oz. per ton.*	*Per ton.*
1	0.30	Trace.	$0.18
2	0.20	Trace.	.12
4	None.	None.	....
5	0.15	None.	.09
6	None.	None.	....
7	0.30	0.05	1.18
8	0.15	Trace.	.09

[a] Column added by W. Lindgren.

At the writer's request Mr. Bowen repeated No. 7 on new material from the same original sample. This time he obtained 0.45 ounce silver and no gold; total value, 27 cents.

Mr. Eckfeldt states that he used 1 A. T. ore, 3 A. T. litharge, 2 A. T. soda, and ½ A. T. borax. No niter was added. His results are as follows:

Assays of samples by J. B. Eckfeldt.

No.	Silver.	Gold.	Total value.[a]
	Oz. per ton.	*Oz. per ton.*	*Per ton.*
9	0.3	0.01	$0.38
10	.35	Trace.	.21
11	Trace.	Trace.	....
12	.5	.02	.70
13	.4	Trace.	.24
14	Trace.	Trace.	....
16	.2	Trace.	.12

[a] Column added by W. Lindgren.

As statements were made that the shales examined contained considerable quantities of zinc (from 2 to 20 per cent), and certificates to this effect were shown me by local chemists, it was decided to test a few samples for zinc and also for copper. Samples 1, 5, and 8, respectively, from the quarry pits of Miller's, Gage's, and the Pioneer Company's mills were selected and examined by Dr. E. T. Allen, of the United States Geological Survey. These samples showed no trace of zinc or copper. The concretions in the shale just below the Fort Hays limestone (Septaria horizon) contain a brown carbonate of lime, which is frequently mistaken for zinc blende.[a]

SUMMARY AND CONCLUSIONS.

Nineteen samples of Benton shale were collected in Ellis and Rush counties, Kans., chiefly along Smoky Hill River. These samples were taken with great care, each representing the average of a certain thickness of beds, in order to ascertain whether these shales contain gold and silver and whether, if so, they may be considered as of economic value. The majority of the samples were collected in pits and quarries from which material had been extracted by other parties for the purposes of assays or treatment in gold mills. These samples were first assayed for gold by myself, then by Dr. E. T. Allen. No gold was found in any of the samples. The silver could not be determined with great accuracy, for some pure silver was added in order to collect any gold that might be present, but there was certainly not more than a small fraction of an ounce in any one of the samples.

[a] E. Haworth, Mineral Resources of Kansas for 1897.

The same samples, except No. 3, of which sufficient material did not remain, were then assayed jointly by Dr. Allen and myself. Twelve samples showed the presence of small amounts of silver up to 6 cents per ton in value, while in 6 no silver or only doubtful traces were found. No. 5 showed 10 cents of gold per ton, and No. 13 a trace of gold. No gold was found in the remaining 16 samples.

Samples 1, 2, 4, 5, 6, 7, and 8 were assayed by Mr. W. F. Bowen, acting assayer of the mint bureau. In five of these small values of silver were found, ranging up to 27 cents per ton. In two of the samples no silver was found. One of the samples (No. 7) gave $1 of gold per ton; this assay was repeated, and this time no gold was found. Traces of gold were found in three samples, and in three samples of the seven no gold was found.

Samples 9, 10, 11, 12, 13, 14, and 16 were then assayed by Mr. Jacob B. Eckfeldt, assayer of the mint in Philadelphia. In five of these silver was found, ranging up to 30 cents per ton, while two samples yielded only a trace. No. 12 gave 40 cents of gold per ton, and No. 9 gave 20 cents per ton, while traces of gold were found in the remaining five samples. In all, 77 assays were made of material taken from the 19 samples.

The results indicate that minute quantities of silver are often contained in these shales and that some samples show the presence of very small quantities of gold. The same samples do not always give the same results when repeated, which goes to confirm the statement on page 5, that the metals when present are somewhat unevenly distributed through the rock. None of the samples contain silver or gold in economically important quantities. While, of course, it is impossible to say what may be contained in those parts of the shale beds which have not been assayed, it is extremely improbable that this material will ever be of economic importance as a silver or gold ore.

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PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Bulletin No. 202.]

The serial publications of the United States Geological Survey consist of (1) Annual Reports, (2) Monographs, (3) Professional Papers, (4) Bulletins, (5) Mineral Resources, (6) Water-Supply and Irrigation Papers, (7) Topographic Atlas of the United States—folios and separate sheets thereof, (8) Geologic Atlas of the United States—folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists may be had on application.

The Bulletins and Professional Papers treat of a variety of subjects, and the total number issued is large. They have therefore been classified into the following series: A, Economic geology; B, Descriptive geology; C, Systematic geology and paleontology; D, Petrography and mineralogy; E, Chemistry and physics; F, Geography; G, Miscellaneous; H, Forestry. This Bulletin is the eighteenth in Series A, the complete list of which follows. (B = Bulletin, PP = Professional Paper.)

SERIES A, ECONOMIC GEOLOGY.

B 21. Lignites of Great Sioux Reservation: Report on region between Grand and Moreau rivers, Dakota, by Bailey Willis. 1885. 16 pp., 5 pls.

B 46. Nature and origin of deposits of phosphate of lime, by R. A. F. Penrose, jr., with introduction by N. S. Shaler. 1888 143 pp.

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B 198. The Berea grit oil sand in the Cadiz quadrangle, Ohio, by W. T. Griswold. 1902. 43 pp., 1 pl.

PP 1. Preliminary report on the Ketchikan mining district, Alaska, with an introductory sketch of the geology of southeastern Alaska, by Alfred Hulse Brooks. 1902. 120 pp., 2 pls.

B 200. Reconnaissance of the borax deposits of Death Valley and Mohave Desert, by Marius R. Campbell. 1902. 23 pp., 1 pl.

B 202. Tests for gold and sliver in shales from western Kansas, by Waldemar Lindgren. 1902. 21 pp.

Correspondence should be addressed to

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8°. 21 pp.

Author.

Lindgren (Waldemar).

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Bulletin No. 203. Series G, Miscellaneous, 23

DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

BIBLIOGRAPHY AND INDEX

OF

NORTH AMERICAN GEOLOGY, PALEONTOLOGY, PETROLOGY AND MINERALOGY

FOR

THE YEAR 1901

BY

FRED BOUGHTON WEEKS

WASHINGTON
GOVERNMENT PRINTING OFFICE
1902

CONTENTS.

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., July 22, 1902.

SIR: I have the honor to transmit herewith the manuscript of a Bibliography and Index of North American Geology, Paleontology, Petrology, and Mineralogy for the Year 1901, and to request that it be published as a Bulletin of the Survey.

Yours respectfully,

F. B. WEEKS.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

BIBLIOGRAPHY AND INDEX OF NORTH AMERICAN GEOLOGY, PALEONTOLOGY, PETROLOGY, AND MINERALOGY FOR THE YEAR 1901.

By Fred Boughton Weeks.

INTRODUCTION.

The preparation and arrangement of the material of the Bibliography and Index for 1901 is similar to that adopted for the previous publications (Bulletins Nos. 130, 135, 146, 149, 156, 162, 172, 188, and 189). Several papers that should have been entered in the previous bulletins are here recorded, and the date of publication is given with each entry.

Bibliography.—The bibliography consists of full titles of separate papers, arranged alphabetically by authors' names, an abbreviated reference to the publication in which the paper is printed, and a brief description of the contents, each paper being numbered for index reference.

Index.—The subject headings, their subdivisions and arrangement, are shown in the classified key to the index, which immediately precedes the index. Reference is made in each entry by author's name and number of article in the Bibliography.

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37 —— On some geological correlations in New Brunswick.
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38 **Bain** (H. Foster). The origin of the Joplin ore deposits [Missouri].
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39 —— [Review of Iowa Geological Survey, Vol. XI.]
Jour. Geol., vol. 9, pp. 547–549, 1901.

40 **Barbour** (Carrie A.). Observations on the concretions of the Pierre shale.
Neb. Acad. Sci., Proc., VII, pp. 36–38, pl. ii, 1901.
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41 **Barbour** (Erwin Hinckley). The unpublished meteorites of Nebraska.
Neb. Acad. Sci., Proc., VII, pp. 34–35, pl. i, 1901.
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42 —— The State [Nebraska] Geological Survey. Report of progress for the summer of 1900.
Neb. Acad. Sci., Proc., VII, pp. 166–169, pls. xiv–xv, 1901.
Gives an account of the work conducted by the State Geological Survey.

43 —— Sand crystals and their relation to certain concretionary forms.
Geol. Soc. Am., Bull., vol. 12, pp. 165–172, pls. 13–18, 1901.
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44 **Barton** (George H.). Outline of elementary lithology
Boston, 112 pp., 1901. (Not seen.)

45 **Bartsch** (Paul), **Dall** (W. H.) and. A new Californian Bittium.
See Dall (W. H.) and Bartsch (Paul), 189.

46 **Bather** (F. A.), assisted by J. W. Gregory and E. S. Goodrich. A treatise on zoology.
A. & C. Black, London, vii + 344 pp., 1900.
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47 **Bayley** (W. S.). [Review of "Elements of mineralogy, crystallography and blowpipe analysis," by A. J. Moses and C. L. Parsons].

Am. Nat., vol. 35, pp. 239–240, 1901.

48 **Beard** (J. Carter). Three characteristic types of American dinosaurs.

Sci. Am., vol. 84, pp. 184–185, fig. 1, 1901.

49 —— Something about ancient American saurians.

Sci. Am., vol. 85, p. 267, 1 fig., 1901.
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50 **Becker** (George F.). Report on the geology of the Philippine Islands, followed by a version of "Ueber Tertiare fossilien von den Philippinen" (1895), by K. Martin.

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Abstract: Am. Geol., vol. 28, pp. 126–127, 1901.
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51 **Beecher** (Charles Emerson). Studies in evolution; mainly reprints of occasional papers selected from the publications of the laboratory of invertebrate paleontology, Peabody Museum, Yale University.

Yale Bicentennial Publications, 638 pp., pls. i–xxxiv, figs. 1–132, 1901. Charles Scribner's Sons, New York.
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52 —— Note on the Cambrian fossils of St. François County, Missouri.

Am. Jour. Sci., 4th ser., vol. 12, pp. 362–363, 1901.
Abstract: Geol. Mag., new ser., dec. 4, vol. 8, pp. 559–561, 1901.
Discusses the fossil evidence indicating that a considerable thickness of the rocks of this region are to be referred to the Cambrian.

53 —— Discovery of eurypterid remains in the Cambrian of Missouri.

Am. Jour. Sci., 4th ser., vol. 12, pp. 364–366, pl. vii, 1901.
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54 —— [Review of "A treatise on zoology," by F. A. Bather, etc.]

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58 —— Laurentian limestones of Baffinland.
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Science, new ser., vol. 13, p. 100, 1901.

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61 **Bishop** (S. E.). Brevity of tuff-cone eruptions.
Am. Geol., vol. 27, pp. 1–5, pl. i, 1901.
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62 **Blake** (William P.). Some salient features in the geology of Arizona, with evidences of shallow seas in Paleozoic time.
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63 —— The evidences of shallow seas in Paleozoic time in southern Arizona.
Abstract: Jour. Geol., vol. 9, pp. 68–69, 1901; Geol. Soc. Am., Bull., vol. 12, p. 493, 1901.
Contains notes on probable lower Paleozoic rocks of the region.

64 —— The caliche of southern Arizona.
Abstract: Eng. & Mg. Jour., vol. 72, pp. 601–602, 1901.
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65 **Blakemore** (William). Pioneer work in the Crows Nest coal areas [Canada].
Can. Mg. Rev., vol. 20, pp. 127–132, 3 figs., 1901; Can. Mg. Inst., Jour., vol. 4, pp. 230–243, 3 figs., 1901.
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66 **Blasdale** (Walter C.). Contribution to the mineralogy of California.

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67 **Blatchley** (W. S.). Oolite and oolitic stone for Portland cement manufacture.

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68 —— The petroleum industry in Indiana in 1900.

Ind. Dept. of Geol. and Nat. Res., 25th Ann. Rept., pp. 481–527, and map, 1901.

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69 —— and **Ashley** (George H.). The lakes of northern Indiana and their associated marl deposits.

Ind. Dept. of Geol. and Nat. Res., 25th Ann. Rept., pp. 31–321, pls. 6–12, figs. 1–70, 1901.

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70 **Bibbins** (A. W.). Occurrence of zoisite and thulite near Baltimore [Maryland].

Am. Jour. Sci., 4th ser., vol. 11, pp. 171–172 (½ p.), 1901.

From notes by the late John W. Lee.

71 **Bishop** (Irving P.). Oil and gas in southwestern New York.

N. Y. State Mus., 53d Ann. Rept., vol. 1, pp. r107–r134, 1901.

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72 **Böse** (Emil). Ein Profil durch den Ostabfall der Sierra Madre Oriental von Mexico.

Zeit. deut. geol. Gesell., Band 53, heft 2, pp. 173–210, figs. 1–8, 1901.

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73 **Bownocker** (J. A.). The Corning oil and gas field.

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75 —— [Review of "Géologie et minéralogie appliquées. Les minéraux et leur gisements," by Henri Charpentier.]

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76 —— Origin of ripple marks.

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77 **Brewer** (William M.). Texada Island, British Columbia.
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78 **Broadhead** (Garland C.). History of geological surveys in Missouri.
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80 **Brooks** (Alfred Hulse). A new occurrence of cassiterite in Alaska.
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80*a* —— An occurrence of stream tin in the York region, Alaska.
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81 —— and **Collier** (Arthur J.). Glacial phenomena of the Seward Peninsula [Alaska].
Abstract: Science, new ser., vol. 13, pp. 188-189, 1901.
Abstract of paper read before the Geological Society of Washington.

82 —— **Schrader** (F. C.) and. Some notes on the Nome gold region of Alaska.
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83 **Brown** (Arthur Erwin). On some points in the phylogeny of the primates.
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85 —— On sussexite, a new borate from Mine Hill, Franklin Furnace, Sussex County, New Jersey.
Yale Bicentennial publications, Cont. to Mineral. and Petrog., pp. 33-36, 1901. (From Am. Jour. Sci., vol. 46, pp. 240-243, 1868.)

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87 —— On the chemical composition of durangite.
Yale Bicentennial publications, Cont. to Mineral. and Petrog., pp. 45-47, 1901. (From Am. Jour. Sci., vol. 11, pp. 464-465, 1876.)

88 —— and **Dana** (Edward S.). On a new and remarkable mineral locality at Branchville, in Fairfax County, Connecticut; with a description of several new species occurring there. First paper.
Yale Bicentennial publications, Cont. to Mineral. and Petrog., pp. 48-71, 1901. (From Am. Jour. Sci., vol. 16, pp. 33-46, 1878.)

89 **Brush** (George J.) and **Dana** (Edward S.). Second Branchville paper.

Yale Bicentennial publications, Cont. to Mineral. and Petrog., pp. 72–80, 1901. (From Am. Jour. Sci., vol. 17, pp. 359–360, 1879.)

90 —— —— Third Branchville paper.

Yale Bicentennial publications, Cont. to Mineral. and Petrog., pp. 81–85, 1901. (From Am. Jour Sci., vol. 18, pp. 45–50, 1879.)

91 —— —— Fourth Branchville paper—Spodumene and the results of its alteration.

Yale Bicentennial publications, Cont. to Mineral. and Petrog., pp. 86–104, 1901. (From Am. Jour. Sci., vol. 20, pp. 257–284, 1880.)

92 —— —— Fifth Branchville paper, with analyses of several manganesian phosphates by Horace L. Wells.

Yale Bicentennial publications, Cont. to Mineral. and Petrog., pp. 105–120, 1901. (From Am. Jour. Sci., vol. 39, pp. 201–216, 1890.)

93 **Buchan** (J. S.). Was Mount Royal an active volcano?

Can. Rec. Sci., vol. 8, pp. 321–328, 1901.

Abstract: Am. Geol., vol. 27, p. 313, 1901.

Discusses the geologic history of Mount Royal.

94 **Buckley** (Ernest Robertson). The clays and clay industries of Wisconsin.

Wis. Geol. and Nat. Hist. Surv., Bull. No. 7, Part I, 304 pp., pls. i–lv 1901.

Describes the composition, classification, and properties of clays and the occurrence and distribution of clay deposits in Wisconsin. Includes map of the State, showing the distribution of the various clay beds.

95 —— Ice ramparts.

Wis. Acad. Sci. Arts and Letters, Trans., vol. 13, pt. I, pp. 141–157, pls. i–xiii, 1901.

Describes the expansion and contraction of ice and their resulting deformations.

96 **Burk** (W. E.). The fluorspar mines of western Kentucky and southern Illinois.

Min. Ind. for 1900, pp. 293–295, 1901.

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97 **Burr** (Henry T.). The structural relations of the amygdaloidal melaphyr in Brookline, Newton, and Brighton, Mass.

Harvard Coll., Mus. Comp. Zool., Bull., vol. 38, pp. 53–68, pls. 1–2, figs. 1–3, 1901.

Abstracts: Am. Geol., vol. 27, p. 319, 1901. Am. Jour. Sci., 4th ser., vol. 12, pp. 80–81, 1901.

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98 **Burritt** (Chas. H.). The Coal Measures of the Philippines.

U. S. War Dept., Rept. to the U. S. Military Governor in the Philippines, 256 pp., 1901. (Not seen.)

99 **Byrne** (P.). Marble formations of the Cahaba River, Alabama.
Eng. and Mg. Jour., vol. 72, p. 400, 1901.
Describes the general character and distribution of the marble.

C.

100 **Calvin** (Samuel). Geology of Page County [Iowa].
Iowa Geol. Surv., vol. 11, pp. 400–460, figs. 28–37, and map, 1901.
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101 —— Concerning the occurrence of gold and some other mineral products in Iowa.
Am. Geol., vol. 27, pp. 363–372, 1901.
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102 **Campbell** (Douglas H.). [Review of "Studies in fossil botany," by D. H. Scott.]
Am. Nat., vol. 35, pp. 73–77, 1901.

103 **Campbell** (John T.). Evidence of a local subsidence in the interior [Indiana].
Jour. Geol., vol. 9, pp. 437–438, 1901.
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104 **Campbell** (Marius R.). Hypothesis to account for the extra-Glacial abandoned valleys of the Ohio Basin.
Abstracts: Geol. Soc. Am., Bull., vol. 12, p. 462 (½ p.), 1901.
Science, new ser., vol. 13, pp. 98–99, 1901.
Discusses their formation as due to formation and persistence of local ice dams.

105 —— Charleston Folio—West Virginia.
U. S. Geol. Surv., Geol. Atlas of U. S., Folio No. 72, 1901.
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106 **Carter** (O. S. C.). Artesian wells as a water supply for Philadelphia.
Franklin Inst., Jour., Jan., 1893. (Not seen.)

107 —— Artesian wells.
Franklin Inst., Jour., Sept., 1893. (Not seen.)

108 —— Anthracite coal near Perkiomen Creek.
Franklin Inst., Jour., August, 1894. (Not seen.)

109 —— Drilling for oil and natural gas in the vicinity of Philadelphia.
Franklin Inst., Jour., Sept., 1894. (Not seen.)

110 **Carter** (O. S. C.). Ferruginized tree.
Franklin Inst., Jour., March, 1896. (Not seen.)

111 —— The Upper Schuylkill River.
Franklin Inst., Jour., Nov., 1897. (Not seen.)

112 —— Denver's water supply.
Phila. Sunday Times, Oct. 22, 1899. (Not seen.)

113 —— The Grand Canyon of the Colorado.
Phila. Sunday Times, Dec. 24 and 31, 1899. (Not seen.)

114 —— Denver's water supply.
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115 —— Limestones in vicinity of Philadelphia, and hydraulic cement.
Phila. Times, April 8, 1900. (Not seen.)

116 —— The source of Camden's [New Jersey] artesian water supply.
Published in the Philadelphia Sunday Times, June 10, 1900. (Not seen.)

117 —— The petrified forest of Arizona.
Published in the Philadelphia Sunday Times, July 8, 1900. (Not seen.)

118 —— The erosion of the shore line at Atlantic City—land made and lost.
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119 —— Atlantic City's [New Jersey] deep artesian well.
Published in the Philadelphia Sunday Times, Aug. 24, 1901. (Not seen.)

120 **Case** (E. C.). Systematic Paleontology, Eocene Reptilia.
Md. Geol. Surv., Eocene, pp. 95–98, pls. x–xi, 1901.

121 **Catlett** (Charles). Coal-outcrops.
Am. Inst. Mg. Engrs., Trans., vol. 30, pp. 559–566 and 1005–1109, 1901.
Mines and Minerals, vol. 21, pp. 255–257, 3 figs., 1901.
Discusses the variations in character of the strata of outcrop and the conditions some distance under cover.

122 **Chalmers** (Robert). Notes on the Pleistocene marine shore lines and landslips of the north side of the St. Lawrence valley.
Can. Geol. Surv., new ser., vol. 11, Rept. J, Appendix I, pp. 63–70, 1901. Published in 1900.
Describes the shore lines and the occurrence of the landslips.

123 —— The sources and distribution of the gold bearing alluvions of Quebec.
Ottawa Nat., vol. 15, pp. 33–36, 1 fig., 1901.
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124 **Chamberlin** (Thomas C.). [Geologic terminology.]
Jour. Geol., vol. 9, pp. 267-270, 1901.

125 —— [Review of "The Norwegian North polar expedition, 1893-1896. Scientific results, Vol. II.]
Jour. Geol., vol. 9, pp. 273-275, 1901.

126 —— [Review of "Meteorological observations of the second Wellman expedition," by Evelyn B. Baldwin.]
Jour. Geol., vol. 9, pp. 276-278, 1901.

127 —— On a possible function of disruptive approach in the formation of meteorites, comets, and nebulæ.
Jour. Geol., vol. 9, pp. 369-392, pl. 1, 1901.
Discusses the possibility of mass disruption without collision and the probable effects.

128 —— [Review of "Rival theories of cosmogony," by O. Fisher.]
Jour. Geol., vol. 9, pp. 458-465, 1901.

129 —— Report on some studies relative to primal questions in geology.
Abstract: Sci. Am. Suppl., vol. 52, p. 21504, 1901.

130 —— On Lord Kelvin's address on the age of the earth as an abode fitted for life.
Smith. Inst., Ann. Rept., 1899, pp. 223-246, 1901.

131 **Chance** (H. M.). Gold ores of the Black Hills, South Dakota.
Am. Inst. Mg. Engrs., Trans., vol. 30, pp. 278-285, 1901.
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132 —— The iron-mines of Hartville, Wyoming.
Am. Inst. Mg. Engrs., Trans., vol. 30, pp. 987-1003, 1 fig., 1901.
Describes the occurrence and character of the ore bodies and gives detailed descriptions of the mine workings.

133 **Charles** (H. W.). Dakota sandstone in Washington County, [Kansas].
Kans. Acad. Sci., Trans., vol. 17, p. 194, 1901.
Describes its general characteristics in this county.

134 **Charlton** (O. C.). Note on the Mort and Bluff meteorites.
Texas Acad. Sci., Trans., vol. 4, pp. 83-84, 1901.
Brief description of occurrence and character.

135 **Chatard** (T. M.) and **Whitehead** (Cabell). An examination of the ores of the Republic mine, Washington.
Am. Inst. Mg. Engrs., Trans., vol. 30, pp. 419-423, 1901.
Describes the chemical studies made of these gold and silver ores.

136 **Chester** (Albert H.). Mineralogical notes and explorations.
N. J. Geol. Surv., Ann. Rept. for 1900, pp. 173-188, 1901.
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137 **Chibas** (Eduardo J.). Manganese mining in Cuba.
Mines and Minerals, vol. 21, pp. 295–296, 1901.
Abstract of report on the manganese mines near Santiago.

138 **Cilley** (Frank H.). Some fundamental propositions in the theory of elasticity. A study of primary or self-balancing stresses.
Am. Jour. Sci., 4th ser., vol. 11, pp. 269–290, 1901.
Discusses briefly the application of the theory to the study of the inner condition of the earth.

139 **Clapp** (Frederick G.). Geological history of the Charles River [Massachusetts].
Tech. Quart., vol. 14, pp. 171–201, figs. 1–13, 255–269, figs. 14–17, 1901.
Describes the various stages of the river's development and their causes, its relation to the geologic structure and the Tertiary and Glacial history of the region.

140 **Clark** (William Bullock) and **Martin** (George Curtis). The Eocene deposits of Maryland.
Md. Geol. Surv., Eocene, pp. 21–92, pls. 1–14, 1901.
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141 —— —— Eocene Mollusca.
Md. Geol. Surv., Eocene, pp. 122–203, pls. xvii–lvii, 1901.

142 —— —— Eocene Molluscoidea (Brachiopoda).
Md. Geol. Surv., Eocene, pp. 203–205, pl. 58, 1901.

143 —— —— Eocene Echinerdomata.
Md. Geol. Surv., Eocene, pp. 232–233, pl. 62, 1901.

144 **Clarke** (John M.). The Oriskany fauna of Becraft Mountain, Columbia County, N. Y.
N. Y. State Mus., 53rd Ann. Rept., vol. 2, pp. 6–101, pls. 1–9, and geologic map, 1901.
See Clarke (J. M.), No. 971, in U. S. Geological Survey Bulletin, No. 188.

145 —— Limestones of central and western New York interbedded with bituminous shales of the Marcellus stage, with notes on the nature and origin of their faunas.
N. Y. State Mus., Bull. No. 49, pp. 115–138, pl. 8, figs. 1–2, 1901.

146 —— New Agelacrinites.
N. Y. State Mus., Bull. No. 49, pp. 182–198, pl. 10, figs. 1–7, 1901.
Reviews the literature regarding these forms and describes three new species.

147 —— Value of Amnigenia as an indicator of fresh water deposits during the Devonic of New York, Ireland and the Rhineland.
N. Y. State Mus., Bull. No. 49, pp. 199–203, pl. 11, 1901.

148 **Clarke** (John M.). The Maryland Eocene book.
Science, new ser., vol. 14, p. 27, 1901.
Gives a brief review of this publication.

149 **Claypole** (E. W.). Notes on petroleum in California.
Am. Geol., vol. 27, pp. 150–159, 1901.
Describes the physiographic features of the oil areas, the general geology, and the source of the oil and gas.

150 —— The Sierra Madre near Pasadena [California].
Abstracts: Jour. Geol., vol 9, pp. 69–70, 1901; Geol. Soc. Am., Bull., vol. 12, p. 494, 1901.
Contains notes on the Tertiary strata and igneous rocks of the region.

151 **Clements** (J. Morgan), **Van Hise** (C. R.) and. The Vermilion iron-bearing district.
See Van Hise (C. R.), 759.

152 **Coleman** (Arthur P.). Glacial and interglacial beds near Toronto [Canada].
Jour. Geol., vol. 9, pp. 285–310, figs. 1–2, 1901.
Describes the glacial history, the variations in climate and their effect on the then existing faunas and floras, and the glacial deposits of the region.

153 —— Marine and fresh-water beaches of Ontario.
Geol. Soc. Am., Bull., vol. 12, pp. 129–146, figs. 1–2, 1901.
Abstract: Science, new ser., vol. 13, p. 136, 1901.
Describes the marine deposits, shell gravels, and beaches of the region.

154 —— The Vermilion River placers [Ontario].
Ontario Bureau of Mines, Rept. for 1901, pp. 151–159, 1 fig., 1901.
Describes the character and distribution of the placers.

155 —— Iron ranges of the Lower Huronian [Ontario].
Ontario Bureau of Mines, Rept. for 1901, pp. 181–211, pls. 25–28, 1901.
Describes the character and occurrence of the iron-ore bodies of various localities, and the petrographic characters of some of the associated rocks. Discusses the origin of some of the ores and includes notes on the Pleistocene geology.

156 —— Sea beaches of eastern Ontario.
Ontario Bureau of Mines, Rept. for 1901, pp. 215–227, pls. 29–30, 1901.
Contains notes on the Leda clay and Saxicava sand, and describes the character and occurrence of the beach sands and gravels and their faunas.

157 **Collie** (George Lucius). Wisconsin shore of Lake Superior.
Geol. Soc. Am., Bull., vol. 12, pp. 197–216, figs. 1–2, 1901.
Describes the general geology of the region, the shore formations and beach phenomena, and the characters of the wave erosion and its topography.

158 **Collie** (George Lucius). Physiography of Wisconsin.
Am. Bur. Geog., Bull., vol. 2, 20 pp., Sept., 1901. (Not seen.)

159 **Collier** (Arthur J.), **Brooks** (Alfred H.) and. Glacial phenomena of the Seward Peninsula [Alaska].
See Brooks (A. H.) and Collier (A. J.), 81.

160 **Collins** (G. E.). Vein structure at the Reynolds mine, Georgia.
Eng. and Mg. Jour., vol. 72, pp. 68–70, figs. 1–11, 1901.
Discusses the vein phenomena in the auriferous crystalline rocks of the region.

161 **Comstock** (Theodore B.). The geology and vein phenomena of Arizona.
Am. Inst. Mg. Engrs., Trans., vol. 30, pp. 1038–1101, fig. 1, 1901.
Gives a general description of the mineral regions. Discusses the orographic disturbances and their effects on ore deposition, and describes the stratigraphic succession in the state.

162 **Comstock** (W. J.), **Allen** (O. D.) and. Bastnasite and tysonite from Colorado.
See Allen (O. D.) and Comstock (W. J.), 11.

163 **Cooper** (A. S.). The origin and occurrence of petroleum in California.
Min. Ind. for 1901, pp. 505–509, fig. 1, 1901.
Describes the occurrence and character of the oil.

164 **Corless** (C. V.). The Coal Creek colliery of the Crows Nest Pass Coal Co. [Canada].
Can. Mg. Rev., vol. 20, pp. 60–67, 16 figs., 1901.
Can. Mg. Inst., Jour., vol. 4, pp. 155–173, 11 figs., 1901.
Gives a general description of the geological occurrence of the coal.

165 **Courtis** (W. M.). [In discussion of paper by G. O. Smith and Bailey Willis on "The Clealum iron ores, Washington."]
Am. Inst. Mg. Engrs., Trans., vol. 30, pp. 1116–1117, 1901.
Gives additional analyses of these ores.

166 **Cowles** (Henry C.). The relation between baseleveling and plant distribution.
Abstract: Science, new ser., vol. 13, pp. 372–373, 1901.

167 **Cragin** (F. W.). A study of some teleosts from the Russel substage of the Platte Cretaceous series.
Colo. Coll. Stud., vol. 9, pp. 25–37, 2 pls., 1901. (Not seen.)

168 **Crane** (W. R.). Kansas coal mining.
Eng. and Mg. Jour., vol. 72, pp. 748–752, 7 figs., 1901.
Describes the distribution and characters of the coal-bearing strata.

169 **Crosby** (W. O.). [Reviews of "Granites of southern Rhode Island and Connecticut, with observations on Atlantic Coast granites in general" by J. F. Kemp; "Contact metamorphism of a basic igneous rock" by U. S. Grant; "Suggestions regarding the classification of the igneous rocks" by W. H. Hobbs; "The nomenclature of feldspathic granolites" by H. W. Turner; and "Some contact phenomena of the Palisade diabase" by J. D. Irving.]

Am. Geol., vol. 27, pp. 51–54, 1901.

170 —— [Reviews of "A brief review of the titaniferous magnetites" by J. F. Kemp; "The origin of kaolin" by H. Ries; "Igneous complex of Magnet Cove, Arkansas" by H. S. Washington; "A granite-gneiss area in central Connecticut" by L. G. Westgate; and "The origin of nitrates in cavern earths" by W. H. Hess.]

Am. Geol., vol. 27, pp. 119–122, 1901.

171 —— [Review of "The calcareous concretions of Kettle Point, Lambton County, Ontario," by R. A. Daly; and "The granite rocks of the Pikes Peak quadrangle" by E. B. Mathews.]

Am. Geol., vol. 27, pp. 253–254, 1901.

172 —— [Review of "Some principles of rock analysis" by W. F. Hillebrand; and "Analyses of rocks, Laboratory of the U. S. Geological Survey" by F. W. Clarke.]

Am. Geol., vol. 27, pp. 315–316, 1901.

173 —— Are the amygdaloidal melaphyrs of the Boston Basin intrusive or contemporaneous?

Am. Geol., vol. 27, pp. 324–327, 1901.

Reviews a paper by Henry T. Burr.

174 —— The tripolite deposits of Fitzgerald Lake, near St. John, New Brunswick.

Tech. Quart., vol. 14, pp. 124–127, 1901.

Describes the character and origin of the deposit.

175 —— Geological history of the hematite iron ores of the Antwerp and Fowler belt in New York.

Tech. Quart., vol. 14, pp, 162–170, figs. 1–4, 1901.

Describes the character, occurrence, and origin of the hematite ores of the region.

176 **Cross** (Whitman), assisted by Arthur Coe Spencer. General geology, La Plata Folio—Colorado.

U. S. Geol. Surv., Geol. Atlas of U. S., Folio No. 60, 1899.

Describes the geographic and physiographic features, the character and occurrence of the Juratrias, Cretaceous, Eocene, and Pleistocene strata and igneous rocks, and the geological structure. Includes a statement of the general geologic problems of the region.

177 **Cross** (Whitman). Outline of geology. (Silverton quadrangle, Colorado.)

U. S. Geol. Surv., Bull. No. 182, pp. 29–39, 1901.

Describes the general characteristics of the sedimentary and igneous rocks and the structure of the region.

178 **Cummings** (Edgar R.). The use of Bedford as a formational name.

Jour. Geol., vol. 9, pp. 232–233, 1901.

Proposes the name Salem limestone for the Bedford limestone, the latter having been preoccupied.

179 —— Orthothetes minutus, n. sp. from the Salem limestone of Harrodsburg, Indiana.

Am. Geol., vol. 27, pp. 147–149, pl. 15, 1901.

180 —— A section of the upper Ordovician at Vevay, Indiana.

Am. Geol., vol. 28, pp. 361–380, pls. 34–35, 1901.

Gives a detailed section, names the fossils found in each bed, and compares this section with that at Cincinnati. Describes four new species.

181 —— Notes on the Ordovician rocks of southern Indiana.

Ind. Acad. Sci., Proc. for 1900, pp. 200–215, 1901.

Gives section at various localities with notes on the faunas.

182 —— Some developmental stages of Orthothetes minutus n. sp.

Ind. Acad. Sci., Proc. for 1900, pp. 216–218, 1901.

183 **Currie** (P. W.). On the ancient drainage at Niagara Falls.

Can. Inst., Trans., vol. 7, pp. 7–14, 6 pls., 1901.

Describes the course of the preglacial river and discusses its mode of formation.

184 **Cushing** (H. P.). Origin and age of an Adirondack augite andesite.

Abstracts: Geol. Soc. Am., Bull., vol. 12, p. 464 (½ p.), 1901.

Science, new ser., vol. 13, p. 100, 1901.

Brief description of character and occurrence.

185 —— Geology of Rand Hill and vicinity, Clinton County [New York].

N. Y. State Mus., 53d Ann. Rept., vol. 1, pp. r45–r82, and geologic map, 1901.

Describes the general geologic history of the region, and the pre-Cambrian and Paleozoic rocks.

D.

186 **Dall** (William H.). The structure of Diamond Head, Oahu.

Am. Geol., vol. 27, pp. 386–387, 1901.

Refers to the controversy as to the origin of Diamond Head, and states the author's conclusions.

187 —— The morphology of the hinge teeth of bivalves.

Am. Nat., vol. 35, pp. 175–182, 1901.

188 **Dall** (William H.). A gigantic fossil Lucina.
Nautilus, vol. 15, pp. 40-42, 1901.
Describes Lucina megameris from Jamaica

189 —— and **Bartsch** (Paul). A new Californian Bittium.
Nautilus, vol. 15, pp. 58-59, 1901.

190 **Daly** (Reginald A.). The physiography of Acadia.
Harv. Coll., Mus. Comp. Zool., Bull., vol. 38, pp. 73-103, pls. 1-11, 1901.
Abstract: Am. Geol., vol. 27, pp. 317-318, 1901.
Describes the characteristics of the several plateau and lowland areas and discusses their origin.

191 —— Notes on oceanography.
Science, new ser., vol. 13, pp. 951-954, 1901.
Discusses phenomena of marine currents and river deflection.

192 **Dana** (Edward S.). On the composition of the labradorite rocks of Waterville, New Hampshire.
Yale Bicentennial publications, Cont. to Mineral. and Petrog., pp. 387-390, 1901. (From Am. Jour. Sci., 3rd ser., vol. 3, pp. 48-50, 1872.)

193 —— **Brush** (George J.) and. On a new and remarkable mineral deposit at Branchville, in Fairfield County, Connecticut; with a description of several new species occurring there. First paper.
See Brush (G. J.) and Dana (E. S.), 88.

194 —— —— Second Branchville paper.
See Brush (G. J.) and Dana (E. S.), 89.

195 —— —— Third Branchville paper.
See Brush (G. J.) and Dana (E. S.), 90.

196 —— —— Fourth Branchville paper—spodumene and the results of its alteration.
See Brush (G. J.) and Dana (E. S.), 91.

197 —— —— Fifth Branchville paper; with analyses of several manganesian phosphates, by Horace T. Wells.
See Brush (G. J.) and Dana (E. S.), 92.

198 **Darton** (Nelson Horatio). Preliminary description of the geology and water resources of the southern half of the Black Hills and adjoining regions in South Dakota and Wyoming.
U. S. Geol. Surv., 21st Ann. Rept., Pt. IV, pp. 497-599, pls. lviii-cxii, figs. 272-299, 1901.
Abstract: Jour. Geol., vol. 9, pp. 732-734, 1901.
Describes the character and occurrence of the Cambrian, Carboniferous, Juratrias, Cretaceous, Tertiary, and Pleistocene strata, and the water and mineral resources and soils of the region.

199 **Darton** (Nelson Horatio). Comparison of stratigraphy of the Black Hills with that of the Front range of the Rocky Mountains.

Abstracts: Geol. Soc. Am., Bull., vol. 12, p. 478 (¾ p.), 1901; Science, new ser., vol. 13, p. 188, 1901.

200 —— and **Keith** (Arthur). Washington Folio, Dist. of Columbia, Maryland, Virginia.

U. S. Geol. Surv., Geol. Atlas of U. S., Folio No. 70, 1901.

Describes geographic and topographic features, the character and occurrence of Archean rocks and of the Cretaceous, Eocene, Neocene, and Pleistocene strata, the general structure of the Piedmont and Coastal plain regions, and mineral resources of the area.

201 **Davis** (Charles A.). A second contribution to the natural history of marl.

Jour. Geol., vol. 9, pp. 491–506, 1901.

Abstract: Am. Geol., vol. 27, p. 186, 1901.

202 **Davis** (William M.). An excursion to the Grand Canyon of the Colorado.

Harv. Coll., Mus. Comp. Zool., Bull., vol. 38, pp. 108–201, pls. 1–2, figs. 1–18, 1901.

Abstracts: Geol. Soc. Am., Bull., vol. 12, p. 483 (¼ p.), 1901; Geol. Mag., new ser., dec. 4, vol. 8, p. 324, 1901; Science, new ser., vol. 13, p. 138, 1901.

Describes the denudation and displacements of the region and discusses the origin of the drainage system.

203 —— Peneplains of central France and Brittany.

Abstract: Geol. Soc. Am., Bull., vol. 12, pp. 480–487, pls. 44–45, 1901.

Discusses the theory of peneplains.

204 —— Note on river terraces of New England.

Abstract: Geol. Soc. Am., Bull., vol. 12, pp. 483–485, 1 fig., 1901.

Discusses the formation of these terraces.

205 —— Current notes on physiography.

Science, new ser., vol. 13, pp. 152–153, 1901.

Contains notes on the Dalles of the Wisconsin and the islands of southern California.

206 —— Current notes on physiography.

Science, new ser., vol. 13, pp. 275–276, 1901.

Contains abstract of paper by H. W. Turner on the origin of Yosemite Valley.

207 —— Current notes on physiography.

Science, new ser., vol. 13, pp. 351–352, 1901.

Contains abstracts of papers by I. C. Russell on the geology of the Cascade Mountains and by W. T. Lee on the glacier of Mt. Arapahoe.

208 **Davis** (William M.). Current notes on physiography.
Science, new ser., vol. 13, pp. 395–397, 1901.
Contains abstract of paper by Abbe on the physiography of Allegany County, Maryland.

209 —— Current notes on physiography.
Science, new ser., vol. 13, pp. 471–472, 1901.
Contains abstract of paper by Ganong on the physiography of New Brunswick.

210 —— Current notes on physiography.
Science, new ser., vol. 13, pp. 551–552, 1901.
Contains brief abstract of paper by Lindgren, describing the Snake River canyon.

211 —— Current notes on physiography.
Science, new ser., vol. 13, pp. 628–629, 1901.
Contains brief abstract of monograph on the Illinois glacial lobe and describes reversion in river development in Pennsylvania.

212 —— Current notes on physiography.
Science, new ser., vol. 13, pp. 751–753, 1901.
Contains abstracts of second folio of the Topographic atlas of the United States and of paper by Lee on the debris-covered mesas of Boulder, Colorado.

213 —— Current notes on physiography.
Science, new ser., vol. 13, pp. 791–793, 1 fig., 1901.
Contains abstracts of the third folio of the Topographic atlas of the United States by R. T. Hill, and of a paper by Crosby on the Nashua Valley, Massachusetts.

214 —— Current notes on physiography.
Science, new ser., vol. 13, pp. 871–872, 1901.
Gives an abstract of paper by Jones on the Tallulah gorge in Georgia.

215 —— Current notes on physiography.
Science, new ser., vol. 13, pp. 950–951, 1901.
Reviews recently published folios of the Geologic atlas of the United States.

216 —— Current notes on physiography.
Science, new ser., vol. 14, pp. 152–153, 1901.
Gives an abstract of a paper by Matthes on the Glacial sculpture of the Big Horn Mountains.

217 —— Current notes on physiography.
Science, new ser., vol. 14, pp. 299–330, 1901.
Gives an abstract of paper by Shattuck on the Pleistocene problem of the North Atlantic Coastal plain.

218 —— Current notes on physiography.
Science, new ser., vol. 14, pp. 457–459, 1901.
Reviews paper by Spurr on the structure of the Basin ranges.

219 **Davis** (William M.). Current notes on physiography.

Science, new ser., vol. 14, pp. 537–538, 1901.

Contains remarks on glacial lakes in Minnesota, esker lakes in Indiana and the Ontario coast.

220 —— Current notes on physiography.

Science, new ser., vol. 14, pp. 698–699, 1901.

Refers to dikes as topographic features, the character of the plain of St. Lawrence Valley and the question of peneplains.

221 —— Current notes on physiography.

Science, new ser., vol. 14, pp. 778–779, 1901.

Reviews papers by Johnson on the High Plains and by Low on the south shore of Hudson Strait.

222 —— Current notes on physiography.

Science, new ser., vol. 14, pp. 856–859, 1901.

Reviews Hobbs's paper on the River system of Connecticut and Dowling and Tyrrell on Lake Winnipeg.

223 **Dawson** (George M.). Summary report on the operations of the Geological Survey for the year 1898.

Can. Geol. Surv., new ser., vol. 11, Rept. A, 208, pp., 1901, published in 1899.

224 —— Geological record of the Rocky Mountain region in Canada.

Geol. Soc. Am., Bull., vol. 12, pp. 57–92, 1901.

Gives an account of the physiographic features and a table of geologic formations of the region. Describes the character and occurrence of the rocks of the subdivisions of the Archean, Paleozoic, Mesozoic, and Cenozoic eras.

225 —— Physical history of the Rocky Mountain region in Canada.

Science, new ser., vol. 13, pp. 401–407, 1901.

Contains portion of address delivered before the Geological Society of America.

226 **Day** (David T.). Notes on the occurence of platinum in North America.

Am. Inst. Mg. Engrs., Trans. vol. 30, pp. 702–708, 1901.

Describes the geographic distribution of platinum and its occurrence on the Pacific Coast.

227 **Dean** (Bashford). On two new Arthrodires from the Cleveland shale of Ohio.

N. Y. Acad. Sci., Mem., vol. 2, pp. 86–100, pls. 2–7, figs. 1–2, 1901.

228 —— On the characters of Mylostonia Newberry.

N. Y. Acad. Sci., Mem., vol. 2, pp. 101–109, pls. 7–8, figs. 3–10, 1901.

229 —— Further notes on the relationships of the Arthrognathi.

N. Y. Acad. Sci., Mem., vol. 2, pp. 110–123, figs. 12–18, 1901.

Discusses the position of the Arthrognathi and the systematic arrangement and nomenclature of the structures.

230 **Diller** (Joseph Silas). Geomorphogeny of the Klamath Mountains [California-Oregon].

Abstracts: Geol. Soc. Am., Bull., vol. 12, p. 461 (½ p.), 1901.
Science, new ser., vol. 13, p. 97, 1901.

231 —— Coos Bay Folio—Oregon.

U. S. Geol. Surv., Geol. Atlas of U. S., Folio No. 73, 1901.

Describes the topographic features, the character and the occurrence of the Cretaceous, Eocene, Neocene, and Pleistocene deposits and igneous rocks, and the occurrence of coal and gold.

232 **Dodge** (Richard E.). Landslides of Echo and Vermillion cliffs.

Abstract: Geol. Soc. Am., Bull., vol 12, p. 485 (7 l.), 1901.

233 **Donald** (J. T.). The composition of some Canadian limestones.

Can. Mg. Rev., vol. 20, pp. 67–68, 1901.
Can. Mg. Inst., Jour., vol. 4, pp. 152–154, 1901.

Gives chemical analyses and notes on the economic uses of these limestones.

234 **Douglass** (Earl). New species of Merycochœrus in Montana. Part II.

Am. Jour. Sci., 4th ser., vol. 11, pp. 73–89, figs. 1–5, 1901.
Describes material from Tertiary beds.

234a —— Fossil mammalia of the White River beds of Montana.

Am. Phil. Soc., Trans. new ser., vol. 20, pp. [only separate seen], pl. ix and map, 1901.

Describes the characters of the strata and of the fossi' mammals collected.

235 **Douglas** (James). Record of borings in the Sulphur Spring Valley, Arizona; and of agricultural experiments in the same locality.

Am. Phil. Soc., Proc., vol. 40, pp. 161–163, 1 fig., 1901.
Gives record of well boring in the valley to the depth of 765 feet.

236 **Dowling** (D. B.). Report on the geology of the west shore and islands of Lake Winnipeg.

Can. Geol. Surv., new ser., vol. 11, Rept. F., 100 pp., 2 pls., 10 figs. 1901, published in 1900.

Describes the physiography, the character, occurrence, and faunas of the Ordovician strata and the glacial phenomena of the region.

237 —— The physical geography of the Red River Valley [Canada].

Ottawa Nat., vol. 15, pp. 115–120, pls. 8–9, 1901.
Describes the physiographic history of the region.

238 —— See **Tyrrell** (J. B.), 747.

239 **Dresser** (John A.). A hornblende lamprophyre dike at Richmond, P. Q.

Can. Rec. Sci., vol. 8, pp. 315–320, 1901.

Describes the occurrence of the dike and the characters of the dike rock.

240 **Dresser** (John A.). A preliminary note on an amygdaloidal trap rock in the eastern townships of the Province of Quebec.

Ottawa Nat., vol. 14, pp. 180–182, 1901.

Describes the megascopic and microscopic characters of the rock.

241 —— On the petrography of Mt. Orford.

Am. Geol., vol. 27, pp. 14–21, 1901.

Describes occurrence and character of diabase, gabbro-diorite, serpentine, and ophicalcite, and gives a summary of the geologic history of the region.

242 —— On the petrography of Shefford Mountain [Quebec].

Am. Geol., vol. 28, pp. 204–213, pl. 21, 1901.

Describes petrographic characters of essexite, nordmarkite, and pulaskite, and discusses their relations.

243 **Dryer** (Charles R.). Certain peculiar eskers and esker lakes of northeastern Indiana.

Jour. Geol., vol. 9, pp. 123–129, figs. 1–2, 1901.

Describes glacial phenomena of the region.

244 —— Lessons in physical geography.

American Book Co., 1901.

Review, Jour. Geol., vol. 9, pp. 638–639, 1901.

245 **Dumble** (E. T.). Cretaceous of Obispo Canyon, Sonora, Mexico.

Texas Acad. Sci., Trans., vol. 4, p. 81, 1901.

Gives brief description of the character of the beds.

246 —— Occurrence of oyster shells in volcanic deposits in Sonora, Mexico.

Texas Acad. Sci., Trans., vol. 4, p. 82, 1901.

Gives brief description of occurrence.

247 —— The iron ores of east Texas.

Eng. & Mg. Jour., vol. 72, p. 104 (½ p.), 1901.

Contains brief notes on the character of the ores.

248 —— Geology of the Beaumont oil fields (Texas).

Houston, Texas, June, 1901. (Not seen.)

249 **Dwight** (W. B.). Fort Cassin beds in the Calciferous limestone of Dutchess County, New York.

Abstract: Geol. Soc. Am., Bull., vol. 12, pp. 490–491, 1901.

Contains notes on the faunas of these beds.

E.

250 **Eakle** (Arthur S.). Mineralogical notes, with chemical analyses by W. T. Schaller.

Univ. of Cal., Dept. of Geol., Bull., vol. 2, pp. 315–326, pl. 9, 1901.

Describes pectolite, zircon crystals, esmeraldaite, coquimbite, and altaite crystals.

[illegible] Systematic paleontology, Eocene Pisces.
[illegible] pp. 98–115, pls. 12–15, 1901.

[illegible] Edestus, Helicoprion, Acanthodes, and other [illegible]iferous sharks.
[illegible] Science, new ser., vol. 14, p. 795, 1901.
[illegible] Suppl., vol. 52, p. 21505, 1901.

[illegible] Edwin C.). The formation as the basis for geologic mapping.
Jour. Geol., vol. 9, pp. 708–717, 1901.
Discusses the problems involved and the application of the proposed system.

254 The emery deposits of Westchester County, New York.
Min. Ind. for 1900, pp. 15–17, 1901.
Describes briefly the character and occurrence of the deposits.

254a A recently discovered extension of the Tennessee white phosphate fields.
U. S. Geol. Surv., Min. Res. for 1900, pp. 812–813, 1901.
Briefly describes occurrence in Decatur County.

255 **Eldridge** (George H.). The asphalt and bituminous rock deposits of the United States.
U. S. Geol. Surv. 22nd Ann. Rept., Pt. 1, pp. 209–452, pls. xxv–lviii, fig. 1–52, 1901.
Describes the character and geologic occurrence of these materials in the United States.

256 **Ells** (R. W.). Report on the geology of the Three Rivers map sheet or northwestern sheet of the eastern townships map, Quebec.
Can. Geol. Surv., new ser., vol. 11. Rept. J., 70 pp., 4 pls., 1901. Published in 1900.
Describes the physiography, the character, and occurrence of the Ordovician, Silurian, and Pleistocene deposits and economic resources of the region.

257 —— The physical features and geology of the Paleozoic basin between the Lower Ottawa and St. Lawrence rivers.
Can. Roy. Soc., Proc. & Trans., 2nd ser., vol. 6, sect. 4, pp. 99–120, 1900.
Describes the character and occurrence of the Paleozoic rocks and the structure of the region.

258 —— The Carboniferous basin of New Brunswick.
Can. Roy. Soc., Proc. and Trans., 2nd ser., vol. 7, sect. 4, pp. 45–56. (Not seen.)
Abstract: Science, new ser., vol. 13, p. 1017, 1901.

259 **Ells** (R. W.). The Devonian of the Acadian provinces.
Can. Rec. Sci., vol 8, pp. 335–343, 1901.
Reviews previous geologic work on the Devonian strata of the region and discusses the problems involved.

260 —— Ancient channels of the Ottawa River [Canada].
Ottawa Nat., vol. 15, pp. 17–30, 1 map, 1901.
Describes glacial phenomena of the region.

261 **Emmons** (Samuel Franklin). The secondary enrichment of ore deposits.
Am. Inst. Mg. Engrs., Trans., vol. 30, pp. 177–217, 1901.
Discusses the process of the secondary enrichment of sulphide ore bodies by transference and reconcentration of the alteration products of the original vein materials by descending surface waters and the chemical reactions which take place. Describes the author's observations in various mining districts and discusses their bearing on these problems.

262 —— Notes on two desert mines in southern Nevada and Utah.
Abstract: Science, new ser., vol. 13, pp. 426–427, 1901.
Contains abstract of paper read before the Geological Society of Washington.

F.

263 **Fairbanks** (Harold W.). Notes on the geology of the Three Sisters, Oregon.
Abstracts: Jour. Geol., vol. 9, p. 73 (½ p.), 1901.
Geol. Soc. Am., Bull., vol. 12, pp. 498–499 (½ p.), 1901.
Brief notes on occurrence of volcanic rocks.

264 —— Pyramid Lake, Nevada.
Pop. Sci. Mo., vol. 58, pp. 405–514, figs. 1–8, 1901.
Describes the geological history of the lake and adjacent region and the characteristics of the volcanic materials.

265 **Fairchild** (Herman LeRoy). Beach structure in Medina sandstone.
Am. Geol., vol. 28, pp. 9–14, pls. ii–iv, 1901.
Review, Jour. Geol., vol. 9, pp. 549–550, 1901.
Discusses the evidences indicating the origin of the ripple marks in the Medina sandstone of New York.

266 **Farnsworth** (P. J.). When was the Mississippi River Valley formed?
Am. Geol., vol. 28, pp. 393–396, 1901.
Discusses the geologic history of the region.

267 **Farrington** (Oliver Cummings). On the nature of the metallic veins of the Farmington meteorite.
Am. Jour. Sci., 4th ser., vol. 11, pp. 60–62, fig. 1, 1901.

268 —— The structure of meteorites.
Jour. Geol., vol. 9, pp. 51–66, figs. 1–6, pp. 174–190, figs. 7–11, 1901.
Describes the various structural features of meteorites and discusses their origin.

269 **Farrington** (Oliver Cummings). The constituents of meteorites.
Jour. Geol., vol. 9, pp. 393–408, and 522–532, 1901.
Describes the character and occurrence of the mineral constituents of meteorites.

270 —— The pre-terrestrial history of meteorites.
Jour. Geol., vol. 9, pp. 623–632, 1901.
Discusses the evidences indicating the probable structure of meteorites before reaching the earth.

271 —— Observations on Indiana caves.
Field Col. Mus., Geol. ser., vol. 1, pp. 247–266, pls. 32–33, figs. 1–8, 1901.

272 **Finlay** (George I.). The granite of Barre, Vermont.
Abstract: Science, new ser., vol. 13, p. 509 (½ p.), 1901. N. Y. Acad. Sci., Annals, vol. 14, pp. 101–102, 1901.
Briefly describes megascopic and microscopic characters.

273 **Fisher** (C. A.). Comparative value of bluff and valley wash deposits as brick material.
Nebr. Board of Agric., Ann. Rept., 1900, pp. 181–184. (Not seen.)

274 —— **Gould** (C. N.) and. The Dakota and Carboniferous clays of Nebraska.
See Gould (C. N.) and Fisher (C. A.), 305.

275 **Fisher** (O.). On rival theories of cosmogony.
Am. Jour. Sci., 4th ser., vol. 11, pp. 414–422, 1901.
Review by T. C. Chamberlin, Jour. Geol., vol. 9, pp. 458–465, 1901.
Discusses the meteoric and nebular theories as to the origin of the earth.

276 —— Mathematical notes to rival theories of Cosmogony.
Am. Jour. Sci., 4th ser., vol. 12, pp. 140–142, 1901.
Contains mathematical notes supplementary to the author's previous paper.

277 **Flink** (Gust.). On the minerals from Narsarsuk on the firth of Tunugdliarfik in southern Greenland.
Meddelelser om Gronland, vol. 24, pp. 11–213, pls. I–IX, 1901. (Not seen.)

278 **Foerste** (August F.). Silurian and Devonian limestones of Tennessee and Kentucky.
Geol. Soc. Am., Bull., vol. 12, pp. 395–444, pls. 35–41, 1901.
Discusses the occurrence and lithologic character of the Ordovician, Silurian and Devonian series in the southern portion of the Cincinnati anticline and discusses the evidences of unconformity. Gives lists of fossils from several formations at various points in the region.

279 —— The Niagara group along the western side of the Cincinnati anticline.
Abstract: Science, new ser., vol. 13, pp. 134–135, 1901.

280 **Foord** (Arthur H.). [Reviews of "Report on the geology and natural resources of the country traversed by the Yellow Head pass route from Edmonton to Tete Jaune Cache, comprising portions of Alberta and British Columbia," by James McErvoy; "On some additional or imperfectly understood fossils from the Cretaceous rocks of the Queen Charlotte Islands, with a revised list of the species from these rocks," by J. F. Whiteaves; and "General Index to the Reports of Progress, 1863 to 1884," by D. B. Dowling.]

Geol. Mag., new ser., dec. iv, vol. 8, pp. 136–139, 1901.

281 **Foote** (H. W.), **Penfield** (S. L.) and. On bixbyite, a new mineral.

See Penfield (S. L.) and Foote (H. W.), 598.

282 —— —— On clinohedrite, a new mineral from Franklin, N. J.

See Penfield (S. L.) and Foote (H. W.), 599.

283 —— **Pratt** (J. H.) and. On wellsite, a new mineral.

See Pratt (J. H.) and Foote (H. W.), 624.

284 **Ford** (W. E.), **Penfield** (S. L.) and. On calavarite.

See Penfield (S. L.) and Ford (W. E.), 600.

285 **Fraas** (E.). [Origin of the Oligocene beds of the Bad Lands, South Dakota.]

Science, new ser., vol. 14, pp. 211–212, 1901.

Contains quotation from letter to Professor Osborn.

286 **Frazer** (Persifor). Memoir of Franklin Platt.

Geol. Soc. Am., Bull., vol. 12, pp. 454–455, 1901.

Gives a brief sketch of his life and a list of his publications.

287 —— The Eighth Session of the International Congress of Geologists.

Am. Geol., vol. 27, pp. 335–342, 1901.

288 **Fuller** (Myron L.). Probable representatives of the pre-Wisconsin till in southeastern Massachusetts.

Jour. Geol., vol. 9, pp. 311–329, figs. 1–6, 1901.

Abstract: Science, new ser., vol. 13, p. 664 (⅓ p.), 1901.

Describes the occurrence and character of the till at various localities and the occurrence of possible interglacial rock disintegration.

289 **Furman** (H. van F.). Gold mining in Alaska.

Mines and Minerals, vol. 21, pp. 433–436, 4 figs., 1901.

Describes character and occurrence of gold ores in southeastern Alaska.

G.

290 **Gannett** (Henry). Profiles of rivers.

U. S. Geol. Surv., Water Supply and Irrigation Papers, No. 44, 100 pp., 11 pls., 1901. Review, Am. Geol., vol. 28, p. 56, 1901.

291 **Geikie** (Archibald). The founders of geology.

Johns Hopkins Univ., George Huntington Williams Memorial lectures, vol. 1, 297 pp., 1901.

Abstract: Am. Jour. Sci., 4th ser., vol. 11, p. 326 (⅓ p.), 1901.

292 **Gidley** (J. W.). Tooth characters and revision of the North American species of the genus Equus.

Am. Mus. Nat. Hist., Bull., vol. 14, pp. 91–142, pls. 18–21, figs. 1–27, 1901.

293 **Gilbert** (Grove Karl). Physical history of Niagara River [New York].

U. S. Geol. Surv., Map of Niagara River and vicinity, 1901.

Abstract: Am. Geol., vol. 27, pp. 375–377, 1901.

294 **Gilpin** (Edwin, jr.). The minerals of Nova Scotia.

Halifax, N. S., 78 pp., 1901. (Not seen.)

295 **Girty** (George H.). The Waverly group in northeastern Ohio.

Abstract: Science, new ser., vol. 13, p. 664 (⅓ p.), 1901.

Gives brief notes on the correlation and succession of the subdivisions.

296 **Gordon** (C. H.). On the origin and classification of gneisses.

Neb. Acad. Sci., Proc. VII, pp. 90–96, 1901.

297 **Gould** (Charles Newton). Notes on the fossils from the Kansas-Oklahoma Red Beds.

Jour. Geol., vol. 9, pp. 337–340, 1901.

Gives a description of the character of the Red beds and of the evidences on which they have been assigned to the Permian. Refers to fossils recently found in the beds.

298 —— Notes on the geology of parts of the Seminole, Creek, Cherokee, and Osage Nations.

Am. Jour. Sci., 4th ser., vol. 11, pp. 185–190, 1901.

This paper is a contribution to the Red Beds problem of the region and indicates that the strata are of Permian and Carboniferous age.

299 —— Tertiary Springs of western Kansas and Oklahoma.

Am. Jour. Sci., 4th ser., vol. 11, pp. 263–268, 1901.

Describes the occurrence of those springs at the contact between the Tertiary and the underlying Cretaceous or Red Bed strata.

300 —— Notes on the Kansas-Oklahoma-Texas Gypsum Hills.

Am. Geol., vol. 27, pp. 188–190, 1901.

Describes the geologic features of the region and discusses the age of the beds.

301 —— The Dakota Cretaceous of Kansas and Nebraska.

Kans. Acad. Sci., Trans., vol. 17, pp. 122-178, pls. 4–12, 1901.

Gives a historical sketch of work on the Dakota group, describes its geographic distribution, character, occurrence, and relations, its economic products, and the general characteristics of its faunas and flora. Includes a bibliography.

302 **Gould** (Charles Newton). On the southern extension of the Marion and Wellington formations.

Kans. Acad. Sci., Trans., vol. 17, pp. 179–181, 1901.

Describes their character and occurrence in Oklahoma.

303 —— The Oklahoma salt plains.

Kans. Acad. Sci., Trans., vol. 17, pp. 181–184, 1901.

Describes the geologic formations of the region and the occurrence and character of the salt plains.

304 —— Oklahoma limestones.

Stone, vol. 23, pp. 351–354, 1901.

Contains notes on the occurrence and character of the limestones.

305 —— and **Fisher** (C. A.). The Dakota and Carboniferous clays of Nebraska.

Nebr. Board of Agric., Ann. Rept. 1900, pp. 185–194. (Not seen.)

306 **Grabau** (Amadeus W.). Guide to the geology and paleontology of Niagara Falls and vicinity.

Buffalo Soc. Nat. Sci. Bull., vol. 7, pp. 1–284, 18 pls., 190 figs., and geologic map; N. Y. State Mus., Bull. No. 45, pp. 1–284, 18 pls., 190 figs. and geologic map, 1901; Review, Am. Geol., vol. 28, pp. 56–57, 1901.

Describes the physiography of the region, the character, occurrence, and distribution of the Silurian and Devonian strata, and the fossils of the Silurian rocks. Includes a bibliography.

307 —— A preliminary geologic section in Alpena and Presque Isle Counties, Michigan.

Am. Geol., vol. 28, pp. 177–189, pl. 20, 1901.

Gives a section of a well 1,250 ft. in depth and describes the character and occurrence of the Devonian strata of the section exposed.

308 —— Recent contributions to the problem of Niagara.

Abstract: Science, new ser., vol. 14, p. 773, 1901; N. Y. Acad. Sci., Annals, vol. 14, p. 139, 1901; Am. Geol., vol. 28, pp. 329–330, 1901.

Contains abstract of paper read before the New York Academy of Sciences.

309 **Granger** (Walter), **Osborn** (Henry F.) and. Fore and hind limbs of Sauropoda from the Bone Cabin quarry [Wyoming].

See Osborn (H. F.) and Granger (W.), 585.

310 **Grant** (C. C.). Opening address. Geological Section [Hamilton Scientific Association].

Hamilton Sci. Assoc., Jour. & Proc. No. 17, pp. 62–77, 2 figs., 1901.

Contains notes on fossils collected near Hamilton, Ontario.

311 —— Niagara Falls as an index of time.

Hamilton Sci. Assoc., Jour. & Proc. No. 17, pp. 78–83, 1 fig., 1901.

312 —— Geological notes, etc.

Hamilton Sci. Assoc., Jour. & Proc. No. 17, pp. 84–96, 1 fig., 1901.

Discusses certain post-glacial problems.

313 **Grant** (Ulysses Sherman). Preliminary report on the copper bearing rocks of Douglas County, Wisconsin.

Wis. Geol. & Nat. Hist. Surv. Bull. No. 6 (2d edition), 83 pp., pls. 1-13, fig. 1, 1901.

Abstract: Am. Geol., vol. 28, pp. 323-324, 1901.

Contains the material of the first edition and the results of the field work of 1900 in the same region.

314 —— Junction of the Lake Superior sandstone and Keweenawan traps in Wisconsin.

Abstract: Geol. Soc. Am., Bull., vol. 13, pp. 6-9, 1901.

Describes the structural relations in Douglas County.

315 **Gratacap** (L. P.). Paleontological speculations.

Am. Geol., vol. 27, pp. 75-100, 1901.

Discusses the life history and development of various fossil forms.

316 —— Paleontological speculations. II.

Am. Geol., vol. 28, pp. 214-234, 1901.

Discusses biological crises.

317 —— The Ward-Coonley collection of meteorites.

Sci. Am. Suppl., vol. 52, pp. 21382-21383, 1901.

Contains notes on the characters of meteorites.

318 **Grave** (Caswell). The oyster reefs of North Carolina; a geological and economic study.

Johns Hopkins Univ., Circ. No. 151, pp. 50-53, 2 figs., 1901.

319 **Greene** (George K.). Contribution to Indiana Paleontology, Part VI.

New Albany, Ind., pp. 42-49, pls. 16-18, 1901.

Describes Devonian fossils from Indiana.

320 —— Contribution to Indiana Paleontology. Part VII.

New Albany, Ind., pp. 50-61, pls. 19-21, 1901.

Describes Devonian and Carboniferous fossils from Indiana.

321 —— Contribution to Indiana Paleontology. Part VIII.

New Albany, Ind., pp. 62-74, pls. 22-24, 1901.

Describes fossils from upper Paleozoic rocks.

322 **Gregory** (Herbert E.). Andesites of the Aroostook volcanic area of Maine.

Yale Bicentennial publications. Cont. to Mineral. and Petrog., pp. 467-480, 1901. (From Am. Jour. Sci., 4th ser., vol. 8, pp. 359-369.)

323 —— [Review of "Physical geography of the Texas region," by R. T. Hill.]

Am. Jour. Sci., 4th ser., vol. 11, pp. 90-91 (½ p.), 1901.

324 —— [Review of "The Pleistocene geology of the south central Sierra Nevada with special reference to the origin of Yosemite Valley," by H. W. Turner.]

Am. Jour. Sci., 4th ser., vol. 11, pp. 242-243, 1901.

325 **Gregory** (Herbert E.). [Review of "Geology of the Boston basin, vol. 1, Part III. The Blue Hills Complex," by W. O. Crosby.]

Am. Jour. Sci., 4th ser., vol. 11, p. 324, 1901.

326 **Gregory** (J. W.) The plan of the earth and its causes.

Am. Geol., vol. 27, pp. 100–119, figs. 1–5, and 134–147, pls. 12–14, figs. 1–16, 1901.

Reviews previous discussions as to the origin of the distribution of the irregularities in the surface of the lithosphere and discusses the pentagonal theory of Élie de Beaumont and the tetrahedral of Green.

327 **Gresley** (W. S.). Possible new coal plants, etc., in coal.

Am. Geol., vol. 27, pp. 6–14, pls. 2–7, 1901.

Describes structures occurring in coal beds which may be of vegetable origin.

328 **Griffith** (William). An investigation of the buried valley of Wyoming [Pennsylvania].

Wyoming Hist. and Geol. Soc., Proc. and Coll., vol. 6, pp. 27–36, with map, 1901.

Abstract: Am. Geol., vol. 28, p. 324, (⅓ p.), 1901.

Describes glacial phenomena of the region.

329 **Grimsley** (G. P.). Kansas mines and minerals.

Kans. Acad. Sci., Trans., vol. 17, pp. 200–207, 1901.

Gives an account of the occurrence of the various economic products of the State.

330 **Hague** (Arnold). Note sur les phénomènes volcaniques Tertiaires de la chaîne d'Absaroka [Wyoming].

Int. Cong. Geol., Compte Rendu, viii session, pp. 364–365, 1901.

331 **Hall** (Christopher W.). Sources of the constituents of Minnesota soils.

Minn. Acad. Nat. Sci., Bull. No. 3, pp. 388–406, 2 figs., 1901.

332 —— Keweenawan area of eastern Minnesota.

Geol. Soc. Am., Bull., vol. 12, pp. 313–342, pls. 27–28, figs. 1–3, 1901.

Describes the topography and physiography, relations, associated formations, the occurrence of the Keweenawan rocks and the general characters and petrography of the Chengwatana series.

333 —— Keewatin area of eastern and central Minnesota.

Geol. Soc. Am., Bull., vol. 12, pp. 343–376, pls. 29–32, 1901.

Describes the occurrence of the series at various localities and their megascopic and microscopic characters. Discusses the evidences as to the age of the series.

334 **Hallock** (William). Peculiar effects due to a lightning discharge on Lake Champlain in August, 1900.

Jour. Geol., vol. 9, pp. 671–672, 1901.

Describes the effect upon the rocks struck by the discharge.

335 **Halse** (Edward). Some silver-bearing veins of Mexico.
North of Eng. Inst. of Mg. & Mch. Engrs., Trans., vol. 50, pp. 202–217, 1901.
Contains brief notes on the vein systems of various mines.

336 **Hamilton** (S. Harbert). Troost's survey of Philadelphia.
Am. Geol., vol. 27, pp. 41–42 (½ p.), 1901.
Calls attention to the location of a copy of Dr. Gerard Troost's publication on the survey of the environs of Philadelphia.

337 —— and **Withrow** (James R.). The progress of mineralogy in 1899, an analytical catalogue of the contributions to that science during the year.
Am. Inst. Mg. Engrs., Bull. No. 2, 1900. (Not seen.)
Abstract: Am. Geol., vol. 27, p. 48 (⅓ p.), 1901.

338 **Hanks** (Henry G.). The deep-lying auriferous gravels and table mountains of California.
San Francisco, 15 pp., 6 pls., 1901. (Not seen.)

339 **arrington** (B. J.). George Mercer Dawson.
Am. Geol., vol. 28, pp. 67–76, pl. 9, 1901.
Describes the life and work of Dr. Dawson.

340 **Harris** (Gilbert D.). Oil in Texas.
Science, new ser., vol. 13, pp. 666–667, 1901.
Contains notes on the thickness of the Tertiary in the vicinity of Beaumont.

341 **Haseltine** (R. M.). Lignite deposits or fields of brown coal in North Dakota.
Mines and Minerals, vol. 21, pp. 545–546, 1901.
Describes character and occurrence of the lignite beds.

342 **Hatcher** (J. B.). Diplodocus Marsh, its osteology, taxonomy and probable habits, with a restoration of the skeleton.
Carnegie Mus., Mem. vol. 1, No. 1, pp. 1–63, pls. 1–13, figs. 1–24, 1901.
Abstract: Science, new ser., vol. 14, pp. 531–532, 1901.

343 —— On the cranial elements and the deciduous and permanent dentations of Titanotherium.
Carnegie Mus., Annals, vol. 1, pp. 256–262, pls. 7–8, 1901. (Not seen.)

344 —— Sabal rigida; a new species of palm from the Laramie.
Carnegie Mus., Annals, vol. 1, pp. 263–264, 1901. (Not seen.)

345 —— The Jurassic dinosaur deposits near Canyon City, Colorado.
Carnegie Mus., Annals, vol. 1, pp. 327–341, 1901. (Not seen.)

346 —— Some new and little known fossil vertebrates.
Carnegie Mus., Annals, vol. 1, 1901. (Not seen.)
Abstract: Am. Geol., vol. 27, p. 379, 1901.

347 **Hatcher** (J. B.). On the structure of the manus in Brontosaurus.
Science, new ser., vol. 14, pp. 1015–1017, 1901.

348 **Hawes** (George W.). On a group of dissimilar eruptive rocks in Campton, New Hampshire.
Yale Bicentennial publications, Cont. to Mineral. and Petrog., pp. 394–399, 1901. (From Am. Jour. Sci., 3d ser., vol. 17, pp. 147–151, 1879.)

349 —— The Albany granite, New Hampshire, and its contact phenomena.
Yale Bicentennial publications. Cont. to Mineral. and Petrog., pp. 400–414, 1901. (From Am. Jour. Sci., 3d ser., vol. 21, pp. 21–32, 1881.)

350 **Haworth** (Erasmus). The Galena-Joplin lead and zinc district.
Min. Ind. for 1899, pp. 658–668, 2 figs., 1900.
Describes the general geology of the region and the occurrence of the ores.

351 —— Petroleum and natural gas in Kansas.
Eng. and Mg. Jour., vol. 72, p. 397, 1901.
Describes the geographic and geologic distribution of the oil and gas.

352 **Hay** (O. P.). [Review of "Beitrag zur systematik und Genealogie der Reptilien" by Max Furbringer.]
Science, new ser., vol. 14, pp. 180–181, 1901.

353 —— The chronological distribution of the elasmobranchs.
Am. Phil. Soc., Trans., new ser., vol. 20, pp. 63–75, 1901.

354 **Hayden** (Horace Edwin). Mr. Ralph Dupuy Lacoe.
Wyoming Hist. and Geol. Soc., Proc. and Coll., vol. 6, pp. 39–54, 1901.
Am. Geol., vol. 28, pp. 335–344, pl. 32, 1901.
Gives a sketch of his life.

355 **Hayes** (Charles Willard). Geological relations of the iron-ores in the Cartersville district, Georgia.
Am. Inst. Mg. Engrs., Trans., vol. 30, pp. 403–419, figs. 1–2, 1901.
Describes the stratigraphy and structure of the region and the character and occurrence of the iron, with notes on the occurrence of ocher and manganese.

356 —— The Arkansas bauxite deposits.
U. S. Geol. Surv., 21st Ann. Rept., Pt. III, pp. 435–472, pls. lx-lxiv, 1901.
Abstract: Jour. Geol., vol. 9, pp. 737–739, 1901.
Describes the general geologic and physiographic relations of the region, and the character, occurrence and origin of the bauxite deposits.

357 —— Tennessee white phosphate.
U. S. Geol. Surv., 21st Ann. Rept., Pt. III, pp. 473–485, pl. lxv, 1901.
Describes the character, occurrence and origin of the phosphates of Perry County.

358 **Heilprin** (A.). Fossils and their teachings.

Sci. Am. Suppl., vol. 52, pp. 21472-21473, 1901.

Lecture delivered before the Philadelphia Academy of Natural Sciences.

359 —— How to interpret the facts of geology.

Sci. Am. Suppl., vol. 52, pp. 21488-21489, 1901.

Abstract of lecture delivered before the Philadelphia Academy of Natural Sciences.

360 **Heiney** (Wm. M.). River bends and bluffs [Indiana].

Ind. Acad. Sci., Proc. for 1900, pp. 197-200, 3 figs, 1901.

361 **Hershey** (Oscar H.). Peneplains of the Ozark Highlands.

Am. Geol., vol. 27, pp. 25-41, 1901.

Describes the Cretaceous and Tertiary peneplains, the Lafayette base level, the Ozarkian valleys and the modern valleys.

362 —— Metamorphic formations of northwestern California.

Am. Geol., vol. 27, pp. 225-245, 1901.

Describes the character, occurrence, and distribution of the pre-Cretaceous rocks of the Klamath Mountains.

363 —— On the age of certain granites in the Klamath Mountains.

Am. Geol., vol. 27, pp. 258-259, 1901.

Brief discussion of the geology of the region and of the intrusive origin of the granite.

364 —— The age of the Kansan drift sheet.

Am. Geol., vol. 28, pp. 20-25, 1901.

Describes the occurrence of the Kansan drift in Missouri and discusses its age.

365 —— The geology of the central portion of the Isthmus of Panama.

Univ. of Cal., Dept. of Geol., Bull., vol. 2, pp. 231-267, and map, 1901.

Describes the physiographic features and the occurrence and character of several formations. Discusses the relations of the crust movements of the region.

366 —— On the age of certain granites in the Klamath Mountains [California].

Abstracts: Jour. Geol., vol. 9, pp. 76-77, 1901; Geol. Soc. Am., Bull., vol. 12, p. 501 (⅔ p.), 1901.

Contains notes on the occurrence of the granites and on the geologic history of the region.

367 —— An unusual type of auriferous deposit.

Science, new ser., vol. 13, pp. 869-871, 1901.

Describes occurrence of gold in a semidecomposed rock mass in California and discusses the mode of deposition of the gold.

368 **Hilgard** (E. W.). A historical outline of the geological and agricultural survey of the State of Mississippi.

Am. Geol., vol. 27, pp. 284-311, 1901.

Gives an account of the work of this organization and a list of its publications.

369 **Hilgard** (E. W.). A sketch of the pedalogical geology of California.

Abstracts: Jour. Geol., vol. 9, pp. 74–75, 1901; Geol. Soc. Am., Bull., vol. 12, pp. 499–500, 1901.

General notes on the soils of the state.

370 **Hill** (B. F.), **Kemp** (J. F.) and. Preliminary report on the pre-Cambrian formations in parts of Warren, Saratoga, Fulton, and Montgomery counties (New York.)

See Kemp (J. F.) and Hill (B. F.), 421.

371 **Hill** (Robert T.). [Review of "A record of the geology of Texas for the decade ending December 31, 1896," by Frederic W. Simonds.]

Science, new ser., vol. 13, pp. 226–227, 1901.

372 —— The coast prairie of Texas.

Science, new ser., vol. 14, pp. 326–328, 1901.

Describes the evidences of differential movements in this region and its bearing on the occurrence of oil.

373 —— Geographic and geologic features of Mexico.

Eng. & Mg. Jour., vol. 72, pp. 561–564, 2 figs., 1901.

Describes the physiography and geology of the country.

374 **Hills** (R. C.). Spanish Peaks folio—Colorado.

U. S. Geol. Surv., Geol. Atlas of U. S., Folio No. 71, 1901.

Describes the geographic features, the character and occurrence of the Cretaceous, Eocene and Neocene strata, the geologic structure, the igneous rocks, and the occurrence of coal and artesian water.

375 **Hitchcock** (C. H.). Tuff cone at Diamond Head, Hawaiian Islands.

Abstracts: Geol. Soc. Am., Bull., vol. 12, p. 462 (¼ p.), 1901; Science, new ser., vol. 13, p. 981 (⅓ p.), 1901.

376 **Hobbs** (William Herbert). The Newark system of the Pomperaug Valley, Connecticut.

U. S. Geol. Surv., 21st Ann. Rept., Pt. III, pp. 7–160, pls. i–xvii, figs. 1–59, 1901.

Gives a sketch of present knowledge regarding this system, describes the character of the sedimentary and igneous rocks, and discusses the deformation and degradation of the region.

377 —— The river system of Connecticut.

Jour. Geol., vol. 9, pp. 469–485, pls. 1–2, figs. 1–2, 1901.

Describes the occurrence and origin of the jointing and faulting in the Pomperaug Valley, the occurrence of certain intersecting series of parallel lines called troughs, which occupy the drainage channels for varying distances.

378 —— Diamondiferous deposits in the United States.

Min. Ind. for 1900, pp. 301–304, 1901.

Briefly describes occurrence and distribution.

379 **Hobbs** (William Herbert). Connecticut rivers.
Science, new ser., vol. 14, pp. 1011–1012, 1901.
Discusses a recent review by W. M. Davis.

380 **Hoffmann** (G. Christian). Report of the section of chemistry and mineralogy.
Can. Geol. Surv., new ser., vol. 11, Rept. R., 55 pp., 1901. Published in 1900.

381 —— On some new mineral occurrences in Canada.
Am. Jour. Sci., 4th ser., vol. 11, pp. 149–153, 1901.

382 —— On some new mineral occurrences in Canada.
Am. Jour. Sci., 4th ser., vol. 12, pp. 447–448, 1901.
Describes datolite and faujasite.

383 **Holder** (Charles F.). A remarkable salt deposit.
Sci. Am., vol. 84, p. 217, 2 figs., 1901.
Describes occurrence of salt on the Salton desert in California.

384 —— Erosion on the Pacific Coast.
Sci. Am., vol. 85, p. 8, 3 figs., 1901.
Decribes some of the physiographic features of the California Coast.

385 **Hollick** (Arthur). A reconnoissance of the Elizabeth Islands [Massachusetts].
N. Y. Acad. Sci., Annals, vol. 13, pp. 387–418, pls. 8–15, 1901.
Describes the physiographic and glacial features of the region.

386 —— Discovery of a mastodon's tooth and the remains of a boreal vegetation in a swamp on Staten Island, N. Y.
N. Y. Acad. Sci., Annals, vol. 14, pt. 1, pp. 67–68, 1901.

387 —— Eocene plantæ.
Md. Geol. Surv., Eocene, pp. 258–261, pl. 64, 1901.

388 **Hopkins** (T. C.). A short discussion of the origin of the Coal Measure fire clays.
Am. Geol., vol. 28, pp. 47–51, 1901.
Reviews the evidences of the formation of fire clays in situ and states that the occurrence of a considerable portion of them is better explained by considering them as transported clays reduced before deposition.

389 —— Graphite and garnet.
Mines and Minerals, vol. 21, p. 352, 1901.
Describes occurrence in Pennsylvania and other regions.

390 **Hovey** (E. O.). The Geological Society of America. Thirtieth Annual meeting.
Sci. Am. Suppl., vol. 51, pp. 20948–20950, 1901.
Contains abstracts of papers read.

391 —— Geology and geography at the Denver meeting of the American Association for the Advancement of Science.
Sci. Am. Suppl., vol. 52, pp. 21504–21505, 1901.

392 **Hovey** (E. O.). The Thirtieth Annual Meeting of the Geological Society of America.

Sci. Am., vol. 84, p. 19, 1901.

Contains brief abstract of some of the papers read.

393 —— [Abstracts of papers read before the thirtieth annual meeting of the Geological Society of America.]

Eng. and Mg. Jour., vol. 71, pp. 49–50, 1901.

394 —— Geology at the fiftieth meeting of the American Association for the Advancement of Science.

Eng. and Mg. Jour., vol. 72, pp. 297–298, 1901.

Contains abstracts of papers read.

395 —— Notes on the Triassic and Jurassic strata of the Black Hills of South Dakota and Wyoming.

Abstract: N. Y. Acad. Sci., Annals, vol. 14, p. 152, 1901.

396 —— See **Whitfield** (R. P.), 822.

397 **Hovey** (Horace C.). The lead and silver mines of Newbury [Massachusetts].

Sci. Am. Suppl., vol. 51, p. 21284, 1901.

Contains notes on the occurrence of the minerals and the geology of the region.

398 **Howe** (Ernest). Experiments illustrating intrusion and erosion.

U. S. Geol. Surv., 21st Ann. Rept., Pt. III, pp. 291–303, pls. xlv–xlvii, figs. 100–102, 1901.

Describes experiments illustrating the formation of laccoliths and the deformation of the invaded strata.

399 **Hubbard** (George D.). [Review of "Preliminary description of the geology and water resources of the southern half of the Black Hills and adjoining regions in South Dakota and Wyoming" by N. H. Darton, and "The High Plains and their utilization" by Willard D. Johnson.]

Jour. Geol., vol. 9, pp. 732–737, 1901.

400 **Hudson** (Edward J.), **Mabery** (Charles H.) and. On the composition of California petroleum.

See Mabery (C. F.) and Hudson (E. J.), 507.

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401 **Ingall** (Elfric Drew). Section of mineral statistics and mines, Annual report for 1898.

Can. Geol. Surv., new ser., vol. 11, Rept. S., 192 pp., 1901. Published in 1900.

Contains statistics of production and notes on the coal fields of Nova Scotia, Manitoba, Northwestern Territories and British Columbia, and on the occurrence of natural gas and oil in Ontario.

J.

402 **Jaggar** (Thomas Augustus). The laccoliths of the Black Hills [South Dakota].

U. S. Geol. Surv., 21st Ann. Rept., Pt. III, pp. 163–290, pls. xviii–xli, figs. 60–99, 1901.

Describes the occurrence of the sedimentary and igneous rocks, and the character, occurrence and distribution of the laccolithic intrusives, and discusses the physiographic form of eroded domes.

403 **Johnson** (D. W.). Notes on the geology of the saline basins of central New Mexico.

Abstract: N. Y. Acad. Sci., Annals, vol. 14, pp. 161–162, 1901.

404 **Johnson** (Willard D.). The high plains and their utilization.

U. S. Geol. Surv., 21st Ann. Rept., Pt. IV, pp. 601–741, pls. cxiii–clvi, figs. 300–329, 1901.

Abstract: Jour. Geol., vol. 9, pp. 734–737, 1901.

Discusses the origin and structure of the region.

405 **Joly** (J.). An estimate of the geological age of the earth.

Smith. Inst., Ann. Rept. 1899, pp. 247–288, 1901.

406 **Jones** (S. P.). The geology of the Tallulah Gorge [Georgia].

Am. Geol., vol. 27, pp. 67–75, pls. 9–11, figs. 1–3, 1901.

Describes the physiographic features of the region and the origin of the gorge.

407 **Julien** (Alexis A.). A study of the structure of fulgurites

Jour. Geol., vol. 9, pp. 673–693, figs. 1–3, 1901.

Gives the results of the study of four fulgurites.

408 —— Erosion by flying sand of the beaches of Cape Cod.

Abstract: N. Y. Acad. Sci., Annals, vol. 14, p. 152, 1901.

409 —— The geology of central Cape Cod [Massachusetts].

Abstract: Am. Geol., vol. 27, p. 44 (½ p.), 1901.

Contains notes on the glacial phenomena of the region.

410 —— [Discussion of paper by J. F. Kemp on "The Cambro-Ordovician outlier at Wellstown, Hamilton County, New York."]

Science, new ser., vol. 13, p. 710, 1901.

Discusses the origin of the sand in the limestones.

K.

411 **Keith** (Arthur). Maynardville folio—Tennessee.

U. S. Geol. Surv., Geol. Atlas of U. S., Folio No. 75, 1901.

Describes the geographic features, the stratigraphy, the character and occurrence of the Cambrian, Silurian, Devonian, and Carboniferous rocks, the geologic structure, and the mineral resources of the region.

412 **Keith** (Arthur), **Darton** (N. H.) and. Washington Folio, District of Columbia, Maryland, Virginia.
See Darton (N. H.) and Keith (Arthur), 200.

413 **Kemp** (James Furman). The Albany meeting of the Geological Society of America.
Science, new ser., vol. 13, pp. 95–100, 133–139, 1901.
Contains abstracts of papers presented.

414 —— The Cambro-Ordovician outlier at Wellstown, Hamilton County, New York.
Abstract: Science, new ser., vol. 13, p. 710, 1901. N. Y. Acad. Sci., Annals, vol. 14, p. 103, 1901.
Contains brief description of occurrence of small outliers of Paleozoic strata within the crystalline area of the region.

415 —— [Review of "Clays of New York, their properties and uses" by Heinrich Ries.]
Science, new ser., vol. 13, pp. 946–947, 1901.

416 —— New asbestos region in northern Vermont.
Abstract: Science, new ser., vol. 14, pp. 773–774, 1901. N. Y. Acad. Sci., Annals, vol. 14, p. 140, 1901.
Describes the occurrence of asbestos associated with serpentine.

417 —— Physiography of Lake George.
Abstract: Science, new ser., vol. 14, p. 774, 1901. N. Y. Acad. Sci., Annals, vol. 14, pp. 141–142, 1901.
Describes briefly the physiographic history of the region.

418 —— Calculation of rock analyses.
School of Mines Quart., vol. 22, p. 75, 1901.
Abstract: Am. Nat., vol. 35, p. 947 (½ p.), 1901.

419 —— New asbestos region in northern Vermont.
Abstract: Am. Geol., vol. 28, p. 330 (¾ p.), 1901.
Abstract of paper read before the N. Y. Academy of Sciences.

420 —— Physiography of Lake George, New York.
Abstract: Am. Geol., vol. 28, pp. 331–332, 1901.
Abstract of paper read before the N. Y. Academy of Sciences.

420a —— Notes on the occurrence of asbestos in Lamoille and Orleans counties, Vermont.
U. S. Geol. Surv., Min. Res. of U. S. for 1900, pp. 862–866, 1901.

421 —— and **Hill** (B. F.). Preliminary report on the pre-Cambrian formations in parts of Warren, Saratoga, Fulton, and Montgomery counties, New York.
N. Y. State Mus., 53d Ann. Rept., pp. r17–r35, pls. 3–8, 1901.
Describes the local geology of various townships of the counties named.

422 **Keyes** (Charles R.). A depositional measure of unconformity.

Geol. Soc. Am., Bull., vol. 12, pp. 173–196, pl. 19, 1901.

Describes the development of the Carboniferous sediments in the Mississippi Valley and Southwestern regions.

423 —— Origin and classification of ore deposits.

Am. Inst. Mg. Engrs., Trans., vol. 30, pp. 323–356, 1901.

Discusses the nature of ore deposits, general methods of ore formation, the classification of ore deposits, and certain other phases of ore deposits.

424 —— Derivation of the terrestrial spheroid from the rhombic dodecahedron.

Jour. Geol., vol. 9, pp. 244–249, 1901.

Discusses Green's hypothesis of the tetrahedral form of the earth.

425 —— Composite genesis of the Arkansas Valley through the Ozark highlands.

Jour. Geol., vol. 9, pp. 486–490, figs. 1–2, 1901.

Discusses the evidences which indicate that there has been but one uplift in the region and that the river eroded its bed as fast as the strata were raised.

426 —— [Review of "Uintacrinus; its structure and relations by Frank Springer; "Oriskany fauna of Becraft Mountain" by J. M. Clarke; and "Stratigraphical succession of the fossil floras of the Pottsville formation in the southern Anthracite coal field" by David White.]

Jour. Geol., vol. 9, pp. 539–547, 1901.

427 —— [Review of "Zinc and lead region of north Arkansas" by John C. Branner.]

Jour. Geol., vol. 9, pp. 634–636, 1901.

428 —— Ore formation on the hypothesis of concentration through surface decomposition.

Am. Geol., vol. 27, pp. 355–362, 1901.

Discusses the evidence as to the derivation of the lead and zinc ores of the Ozark region and their bearing on the origin of ore deposits in general.

429 —— Nomenclature of the Cambrian formations of the St. François Mountains [Missouri].

Am. Geol., vol. 28, pp. 51–53, 1901.

Discusses the validity of certain names applied to the Cambrian formations of the region.

430 —— [Reviews of "Paleozoic faunas of northern Arkansas" by H. S. Williams; "What is an Echinoderm?" by F. A. Bather; and "Structure and relations of Uintacrinus" by Frank Springer.]

Am. Geol., vol. 28, pp. 254–260, 1901.

431 **Keyes** (Charles R.). A schematic standard for the American Carboniferous.

Am. Geol., vol. 28, pp. 299–305, fig. 1, 1901.

Presents a general section of the Carboniferous of the Mississippi Valley and discusses its correlation with other regions.

432 —— [Review of "Geology of eastern Choctaw coal field" by J. A. Taff and G. I. Adams.]

Am. Geol., vol. 28, pp. 318–319, 1901.

433 —— Time values of provincial Carboniferous terranes.

Am. Jour. Sci., 4th ser., vol. 12, pp. 305–309, fig. 1, 1901.

Discusses the time ratios of the several subdivisions of the Carboniferous of the Mississippi Valley region.

434 —— Note on the correlation of the Clarinda well section with the schematic section of the Carboniferous.

Iowa Geol. Surv., vol. 11, pp. 461–463, 1901.

Compares the well section with the general section.

435 —— A depositional measure of unconformity.

Abstract: Science, new ser., vol. 13, pp. 135–136, 1901.

436 —— On a crinoidal horizon in the Upper Carboniferous.

Science, new ser., vol. 13, pp. 915–916, 1901.

Describes its occurrence and its bearing on the stratigraphy of the Mississippi Valley.

437 —— Zone of maximum richness in ore bodies.

Science, new ser., vol. 14, pp. 577–578, 1901.

Contains abstracts of recent papers by Emmons and Weed.

438 —— Horizons of Arkansas and Indian Territory coals compared with those of other trans-Mississippian coals.

Eng. and Mg. Jour., vol. 71, pp. 692–693, 2 figs., 1901.

Discusses the relations of the coal-bearing horizons of the trans-Mississippian region.

439 —— The stratigraphical location of named trans-Mississippian coals.

Eng. and Mg. Jour., vol. 72, p. 198, 1901.

Gives list of geological formations and the coals occurring in each.

440 —— Contiguity of ore deposits of different generic relationships.

Abstract: Eng. and Mg. Jour., vol. 72, pp. 597–598, 1901.

441 —— Diverse origins and diverse times of formation of the lead and zinc deposits of the Mississippi Valley.

Mining and Metallurgy, vol. 24, pp. 715–717, 1901. (Not seen.)

442 **Kindle** (Edward M.). The Devonian fossils and stratigraphy of Indiana.

Ind. Dept. of Geol. and Nat. Res., 25th Ann. Rept., pp. 529–763, pls. i–xxxi, 1901.

Reviews the nomenclature of the formations and describes the lithologic and faunal character of many sections, and the characters of a large number of fossils from the Devonian rocks of the State. Discusses the correlation of the formations.

443 **Kingsley** (J. S.). The origin of the Mammals.

Science, new ser., vol. 14, pp. 193–205, figs. A–E, 1901.

444 **Knapp** (S. A.). Tonopah [Nevada].

Mg. and Sci. Press., vol. 82, p. 231, 1901.

Describes occurrence of gold and silver at this locality.

445 **Knight** (Nicholas). Some Iowa dolomites.

Am. Jour. Sci., 4th ser., vol. 11, pp. 244–246, 1901.

Contains chemical analyses of the dolomites.

446 **Knight** (W. C.). Description of Bates Hole [Wyoming].

Abstracts: Jour. Geol., vol. 9, pp. 70–71, 1901. Geol. Soc. Am., Bull., vol. 12, pp. 495–496, 1901.

Describes the physiographic and geologic features of the region.

447 —— The petroleum fields of Wyoming.

Eng. and Mg. Jour., vol. 72, pp. 358–359, and map, 628–630, 4 figs., 1901.

Describes the geology and character and occurrence of the oil in the several oil-bearing districts of the State.

448 —— The Sweetwater mining district, Fremont County, Wyoming.

Wyom. Univ., School of Mines, 35 pp., 1 map, 1901.

Describes occurrence of gold in this district.

449 —— Geology of the oil fields [Wyoming].

Wyom. Univ., School of Mines, Bull. No. 4, 1901. (Not seen.)

450 —— and **Slosson** (E. E.). The Dutton, Rattlesnake, Arago, Oil Mountain, and Powder River oil fields [Wyoming].

Wyom. Univ., School of Mines, Pet. ser., Bull. No. 4, 57 pp., 1 fig., 2 maps, 1901.

Describes the occurrence and character of the oils in the several districts.

451 —— —— Alkali lakes and deposits [Wyoming].

Wyom. Univ., Exp. Stat., Bull. No. 49, 123 pp., 1 map, 1901.

Describes the character, occurrence, and origin of the deposits of considerable depth.

452 **Knowlton** (Frank Hall). [Report on the Clarno flora, Oregon.]

Univ. of Cal., Dept. of Geol., Bull., vol. 2, pp. 287–291, 1901.

Gives list of fossil plants collected.

453 **Knowlton** (Frank Hall). [Report on the flora of the Mascall formation, Oregon.]

Univ. of Cal., Dept. of Geol., Bull., vol. 2, pp. 308–309, 1901.

Gives list of fossils collected.

454 —— Report on fossil wood from the Newark formation of South Britain, Connecticut.

U. S. Geol. Surv., 21st Ann. Rept., Pt. III, pp. 161–162, 1901.

Briefly describes material.

455 **Kümmel** (Henry B.). Report on Portland cement industry. [New Jersey.]

N. J. Geol. Surv., Ann. Rept. for 1900, pp. 9–101, pls. 1–11, figs. 1–33, 1901.

Describes the composition of Portland cement, and the character and occurrence of the lower Paleozoic rocks from which the materials are derived. Includes detailed descriptions of localities.

456 —— The mining industry. [New Jersey.]

N. J. Geol. Surv., Ann. Rept. for 1900, pp. 197–217, 1901.

Contains statistics and notes on iron, zinc, and copper.

457 —— and **Weller** (Stuart). Paleozoic limestones of Kittatiny Valley, New Jersey.

Geol. Soc. Am., Bull., vol. 12, pp. 147–164, 1901.

Abstract: Science, new ser., vol. 13, p. 134, 1901.

Describes the lithologic and faunal characters of the subdivisions of the Cambrian and Ordovician series and the structure of the region.

458 **Kunz** (George F.). Des progrès de la production des pierres précieuses aux États-Unis.

Int. Cong. Geol., Compte Rendu, viii session, pp. 393–395, 1901.

L.

459 **Laflamme** (J. C. K.). Modifications remarquables causées a l'Embouchere de la Rivière Ste-Anne par l'eboulement de St-Alban.

Can. Roy. Soc., Proc. and Trans., new ser., vol. 6, sect. 4, pp. 175–177, 1900.

460 —— Eboulement à Saint-Luc-de-Vincennes, Rivière Champlain, le 21 Septembre, 1895.

Can. Roy. Soc., Proc. and Trans., new ser., vol. 6, sect. 4, pp. 179–186, 1 fig., 1900.

461 **Lakes** (Arthur). The American Nettie [Colorado].

Mines and Minerals, vol. 21, pp. 241–245, 5 figs., 1901.

Describes the geology of the region and the occurrence of ores in cave deposits.

462 —— Cripple Creek [Colorado].

Mines and Minerals, vol. 21, pp. 276–280, 7 figs., 1901.

Describes volcanic rocks and phenomena of the region.

463 **Lakes** (Arthur). The Curtis coal mine [Colorado].

Mines and Minerals, vol. 21, p. 298 (½ p.), 1901.

Brief description of occurrence and character of coal near Colorado Springs.

464 —— Cave ore deposits [Colorado].

Mines and Minerals, vol. 21, pp. 333–334, 1 fig., 1901.

Describes character and occurrence of ore bodies in the San Juan region.

465 —— The Cerrillos anthracite mines [New Mexico].

Mines and Minerals, vol. 21, pp. 341–342, 1901.

Describes character and occurrence of coal in this region.

466 —— A new coal field [New Mexico].

Mines and Minerals, vol. 21, pp. 375–376, 2 figs., 1901.

Describes the geology of the region and the occurrence of coal.

467 —— The turquoise mines [New Mexico].

Mines and Minerals, vol. 21, pp. 395–396, 1901.

Describes occurrence of turquoise.

468 —— Change of ore bodies with change of country rock.

Mines and Minerals, vol. 21, p. 417, 1901.

Discusses some phenomena accompanying ore deposition.

469 —— Peculiar geological formations of the Southern States.

Mines and Minerals, vol. 21, p. 430, 1901.

Contains notes on the general geology of the region.

470 —— Oil fields of California.

Mines and Minerals, vol. 21, pp. 467–470, 2 figs., 1901.

Describes the general geology of southern California and the occurrence of oil.

471 —— Prospecting for oil in Colorado.

Mines and Minerals, vol. 21, pp. 481–483, 4 figs., 1901.

Describes general geology and occurrence of oil in Colorado.

472 —— Building and monumental stones of Colorado.

Mines and Minerals, vol. 22, pp. 29–30, 5 figs., 1901.

Describes the general characters and occurrence of various building stones.

473 —— Sedimentary building stones of Colorado.

Mines and Minerals, vol. 22, pp. 62–64, 5 figs., 1901.

Describes occurrence and character of building stones from sedimentary strata.

474 —— Petroleum in western North America.

Mines and Minerals, vol. 22, pp. 78–80, 1901.

Describes the occurrence of oil in this region.

475 **Lakes** (Arthur). Prospecting for oil in Colorado.
Mines and Minerals, vol. 22, pp. 107–109, 5 figs., 1901.
Contains notes on the occurrence of oil.

476 —— Oil springs of Rio Blanco County, Colorado.
Mines and Minerals, vol. 22, pp. 150–152, 5 figs., 1901.
Describes the geologic structure and occurrence of oil.

477 —— Some Idaho mining districts.
Mines and Minerals, vol. 22, pp. 203–206, 5 figs., 1901.
Contains notes on the geology of the State and the character and occurrence of ore bodies.

478 —— The geological occurrence of oil in Colorado.
Abstract: Sci. Am. Suppl., vol. 52, p. 21505, 1901.

479 **Lambe** (L. M.). A revision of the general and species of Canadian Paleozoic corals. The Madreporia aporosa and rugosa.
Can. Geol. Surv., Cont. to Can. Paleont., vol. 4, pt. 2, pp. 97–198, pls. 6–18, 1901.
(Not seen.)

480 **Lane** (Alfred C.). Michigan limestones and their uses.
Eng. & Mg. Jour., vol. 71, pp. 662–663, 1 fig., 693–694, and 725, 1901.
Describes the occurrence, character and uses of the limestones derived from the several geologic horizons in Michigan.

481 —— The pre-Glacial surface deposits of Lower Michigan.
Abstract: Science, new ser., vol. 14, pp. 788–799, 1901.
Describes briefly the drainage systems and the character of the bed rock material.

482 **Lawson** (Andrew C.). A feldspar-corundum rock from Plumas County, California.
Abstracts: Jour. Geol., vol. 9, p. 78 (½ p.), 1901. Geol. Soc. Am., Bull., vol. 12, pp. 501–502 (½ p.), 1901.
Gives chemical analysis of the feldspar.

483 —— The drainage features of California.
Abstracts: Jour. Geol., vol. 9, pp. 77–78, 1901. Geol. Soc. Am., Bull., vol. 12, p. 495 (⅔ p.), 1901.
Discusses the causes which have determined the drainage features of the Coast, Klamath and Sierra Nevada ranges.

484 —— Joseph Le Conte.
Science, new ser., vol. 14, pp. 273–277, 1 pl., 1901.
Gives a sketch of his life and work.

484a —— and **Palache** (Charles). The Berkeley Hills [California]. A detail of Coast Range geology.
Univ. of Cal., Dept. of Geol., Bull., vol. 2, pp. 349–450, pls. 10–17, and map, 1901.
Describes the character, occurrence and relations of the formations of the region, erosion intervals, faults, and the microscopic characters of the volcanic rocks.

485 **Le Conte** (Joseph). A century of geology.
Smith Inst., Ann. Rept. for 1900, pp. 265–287, 1901.

486 **Ledoux** (A. R.). Notes on the Oregon nickel prospects.
Can. Mg. Rev., vol. 20, pp. 84–85, 1901.
Can. Mg. Inst., Jour., vol. 4, pp. 184–189, 1901.
Describes the geological relations of the ore bodies and gives a chemical analysis of the ore.

487 **Lee** (Willis T.). The Morrison formation of southwestern Colorado.
Jour. Geol., vol. 9, pp. 343–352, figs. 1–4, 1901.
Describes the character and occurrence of the Jurassic and Cretaceous strata of the region, and discusses the stratigraphic and paleontologic evidences of the age of the Morrison formation.

488 **L'Hame** (Wm. E.). Thunder Mountain, Idaho.
Mines and Minerals, vol. 21, p. 558, 1901.
Describes briefly occurrence of gold in the region.

489 **Leith** (C. K.). Summaries of current North American pre-Cambrian literature.
Jour. Geol., vol. 9, pp. 79–87, and 441–458, 1901.

490 —— **Van Hise** (C. R.) and. The Mesabi district.
See Van Hise (C. R.), 759.

491 **Leonard** (Arthur Gray). The basic rocks of northwestern Maryland and their relation to the granite.
Am. Geol., vol. 28, pp. 135–176, pls. 15–19, 1901.
Describes the geologic occurrence and relations and discusses the origin of the various facies.

492 **LeRoy** (Osmond Edgar). Geology of Rigaud Mountain, Canada.
Geol. Soc. Am., Bull., vol. 12, pp. 377–394, pls. 33–34, 1901.
Abstract: Science, new ser., vol. 13, pp. 136–137, 1901.
Describes the topographic and general geologic features of the region and the microscopic characters of the igneous rocks.

493 **Letson** (Elizabeth J.). Post-Pliocene fossils of the Niagara River gravels.
Buffalo Soc. Nat. Sci., Bull., vol. 7, pp. 238–252, figs. 161–190, 1901.

494 **Leverett** (Frank). Old channels of the Mississippi in southeastern Iowa.
Annals of Iowa, April, 1901. (Not seen.)

495 **Lindgren** (Waldemar). Metasomatic processes in fissure veins.
Am. Inst. Mg. Engrs., Trans., vol. 30, pp. 578–692, fig. 1–30, 1901.
Abstract: Am. Jour. Sci., 3d ser., vol. 11, pp. 243–244 (½ p.), 1901.
Discusses the general features of the changes in rocks contiguous to ore-bearing fissures, and the minerals developed by metasomatic processes in fissure veins. Gives an account of fissure veins in various mining regions classified according to metasomatic processes.

496 **Lindgren** (Waldemar). Trias in northeastern Oregon.
Abstract: Science, new ser., vol. 13, pp. 270–271, 1901.
Describes briefly character and distribution.

497 —— Rare minerals in gold quartz veins of eastern Oregon.
Mg. and Sci. Press., vol. 82, p. 252, 1901.
Gives a chemical analysis of roscoelite and notes on other minerals.

498 **Loomis** (F. B.). On Jurassic stratigraphy in southeastern Wyoming.
Am. Mus. Nat. Hist., Bull., vol. 14, pp. 189–197, pls. 26–27, 1901.
Describes the geologic structure of the region and the character of the Jurassic and Cretaceous sediment of the region.

499 **Low** (A. P.). Report on an exploration of part of the south shore of Hudson Strait and of Niagara Bay [Canada].
Can. Geol. Surv., new ser., vol. 11, Rept. L, 47 pp., 5 pls., 1901. Published in 1899.
Describes the physiography and crystalline rocks of the region.

500 **Lowry** (J. D.). Mining in Lower California.
Eng. & Mg. Jour., vol. 72, pp. 457–458, 1901.
Containes notes on the occurrence of gold, silver, and copper ores.

501 **Lucas** (Frederic A.). A new rhinoceros, Trigonias osborni, from the Miocene of South Dakota.
U. S. Nat. Mus., Proc., vol. 23, pp. 221–223, figs. 1–2, 1901.

502 —— A new dinosaur, Stegosaurus marshi, from the Lower Cretaceous of South Dakota.
U. S. Nat. Mus., Proc., vol. 23, pp. 291–292, pls. 23–24, 1901.

503 —— The pelvic girdle of Zeuglodon, Basilosaurus cetoides (Owen), with notes on other portions of the skeleton.
U. S. Nat. Mus., Proc., vol. 23, pp. 327–331, pls. 5–7, 1901.
Includes section of the Zeuglodon beds.

504 —— A new fossil Cyprinoid, Leuciscus turneri, from the Miocene of Nevada.
U. S. Nat. Mus., Proc., vol. 23, pp. 333–334, pls. 8, 1901.

504a —— A flightless Auk, Mancalla californiensis, from the Miocene of California.
U. S. Nat. Mus., Proc., vol. 24, pp. 133–134, 3 figs., 1901.

505 —— Vertebrates from the Trias of Arizona.
Science, new ser., vol. 14, p. 376, 1901.
Describes briefly material recently collected.

506 **Lyon** (D. A.). Serpentine marbles of Washington.
Mines and Minerals, vol. 21, p. 349, 1901.
Describes the character and occurrence of the serpentine

M.

507 **Mabery** (Charles F.) and **Hudson** (Edward J.). On the composition of California petroleum.

Am. Acad. Arts and Sciences, Proc., vol. 36, pp. 255–283, 1901.

Gives results chemical analyses of petroleum oil from various parts of California.

508 **McBeth** (W. A.). The development of the Wabash drainage system and the recession of the ice sheet in Indiana.

Ind. Acad. Sci., Proc. for 1900, pp. 184–192, 2 figs., 1901.

Describes drainage and glacial phenomena.

509 —— A theory to explain the western Indiana bowlder belts

Ind. Acad. Sci., Proc. for 1900, pp. 192–194, 1901.

Considers they were deposited by floating ice.

510 **Macbride** (Thomas H.). Geology of Clay and O'Brien counties [Iowa].

Iowa Geol. Surv., vol. 11, pp. 463–497, figs. 38–39, and map, 1901.

Describes physiography, the occurrence and character of the Pleistocene beds and the occurrence of economic products.

511 **McCalley** (Henry). The Alabama coal fields.

Mines and Minerals, vol. 21, pp. 446–449, 3 figs., 1901.

Describes the general occurrence and character of the coal.

512 **McCallie** (S. W.). A preliminary report on the roads and road-building materials of Georgia.

Ga. Geol. Surv. Bull. 8, 264 pp., pls. 13–14, 1901. (Not seen.)

513 —— Some notes on the trap dikes of Georgia.

Am. Geol., vol. 27, pp. 133–134, pls. 12–14, 1901.

Describes the character and occurrence of dike rocks which cut the crystalline rocks.

514 **McCaslin** (D. S.). The geology of the artesian basin in South Dakota.

Minn. Acad. Nat. Sci., Bull., vol. 3, pp. 380–388, 1901.

515 **McCormick** (E.). The Santa Fe mining district, Nevada.

Mines and Minerals, vol. 21, p. 407 (½ p.), 1901.

Describes the geologic structure of the region and the occurrence of copper and silver ores.

516 **McEvoy** (James). Report on the geology and natural resources of the country traversed by the Yellow Head Pass route from Edmonton to Tete Jaune Cache, comprising portions of Alberta and British Columbia

Can. Geol. Surv., new ser., vol. 11, Rept. D, 44 pp., pl. 2, 1901. Published in 1900.

Describes the physiography and the general character and occurrence of the Tertiary, Cretaceous, Cambrian and Archean rocks of the region.

517 **McNairn** (W. Harvey). On a large phlogopite crystal.
Am. Jour. Sci., 4th ser., vol. 12, p. 398 (½ p.), 1901.
Briefly describes character and occurrence.

518 **Malcohnson** (James W.). The Sierra Mojada, Coahuila, Mexico, and its ore deposits.
Eng. and Mg. Jour., vol. 72, pp. 705–710, figs. 1–5, 1901.
Contains notes on the geology and ore bodies of the region.

519 **Manning** (P. C.). Glacial potholes in Maine.
Portland Soc. Nat. Hist., Proc., vol. 2, pp. 185–200, pls. 3–4, 1901.
Describes the occurrence and character of the potholes along the coast of Maine and discusses the evidences indicating their origin.

520 **Martin** (Daniel S.). [Minerals at Haddam, Maine.]
Abstract: Am. Geol., vol. 27, p. 44 (6 l.), 1901.
Mentions occurrence of certain minerals.

521 —— Geological notes on the neighborhood of Buffalo.
Abstract: N. Y. Acad. Sci., Annals, vol. 14, pp. 162–163, 1901.

522 **Martin** (George Curtis), **Clark** (William Bullock) and. Eocene Echinerdomata.
See Clark (W. B.) and Martin (G. C.), 143.

523 —— —— Eocene Molluscoidea (Brachiopoda).
See Clark (W. B.) and Martin (G. C.), 142.

524 —— —— Eocene Mollusca.
See Clark (W. B.) and Martin (G. C.), 141.

525 —— —— The Eocene deposits of Maryland.
See Clark (W. B.) and Martin (G. C.), 140.

526 **Martin** (J. O.). The Ontario coast between Fairhaven and Sodus bays [New York].
Am. Geol., vol. 27, pp. 331–334, pls. 26–27, 1901.
Describes the lake shore phenomena of the region.

527 **Martin** (K.). Ueber Tertiare fossilen von der Philippinen.
See Becker (George F.), 50.

528 **Mason** (F. H.). Potters clay at Middle Musquodoboit [Nova Scotia].
Can. Mg. Rev., vol. 20, pp. 175–176, 1 fig., 1901.
Describes occurrence and chemical character of the material.

529 **Matthew** (George F.). Preliminary notice of the Etcheminian fauna of Newfoundland.
New Brunswick Nat. Hist. Soc., Bull., vol. 4, pp. 189–196, pls. i–iii, 1899.
Contains descriptions of several new species.

530 **Matthew** (George F.). Preliminary notice of the Etcheminian fauna of Cape Breton.

New Brunswick Nat. Hist. Soc., Bull., vol. 4, pp. 198–208, pls. i–iv, 1899.

Abstracts: Am. Jour. Sci., 4th ser., vol. 11, p. 396 (⅓ p.), 1901; Am. Geol., vol. 27, p. 49 (½ p.), 1901.

531 —— Acrothyra and Hyolithes—a comparison.

Can. Roy. Soc., Proc. and Trans., vol. 7, sect. 4, pp. 93–106, 1901. (Not seen.)

Abstract: Science, new ser., vol. 13, p. 1018 (⅓ p.), 1901.

532 —— Hyolithes gracilis, and related forms from the Lower Cambrian of the St. John group.

Can. Roy. Soc., Proc. and Trans., vol. 7, sect. 4, pp. 109–111, 1901. (Not seen.)

533 —— [Devonian of the Acadian provinces.]

Can. Rec. Sci., vol. 8, pp. 344–345, 1901.

Discusses recent papers by David White.

534 —— [Review of "Beitrage zur Kenntniss des Siberischen Cambrium I," by E. von Toll.]

Am. Geol., vol. 27, pp. 54–56, 1901.

535 —— Are the St. John plant beds Carboniferous?

Am. Geol., vol. 27, pp. 383–386, 1901.

Discusses the stratigraphic and faunal evidences of the age of the beds.

536 —— Les plus anciennes faunes Paleozoiques.

Int. Cong. Geol., Compte Rendu, viii session, pp. 313–316, 1901.

Gives a résumé of what is known regarding the earliest faunas of eastern Canada.

537 —— A backward step in Paleobotany.

Abstract: Science, new ser., vol. 13, p. 1019 (½ p.), 1901.

Paper read before the Royal Society of Canada.

538 **Matthew** (W. D.). Additional observations on the Creodonta.

Am. Mus. Nat. Hist., Bull., vol. 14, pp. 1–38, figs. 1–17, 1901.

Discusses the classification of the group and revision of genera.

539 **Mayer** (Alfred Goldsborough). [Review of "The variations of a newly arisen species of Medusa."]

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540 **Mead** (J. R.). The Flint Hills of Kansas.

Kans. Acad. Sci., Trans., vol. 17, pp. 207–208, 1901.

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541 **Memminger** (C. G.). Progress in the phosphate mining industry of the United States during 1900.

Min. Ind. for 1900, pp. 513–518, 1901.

Describes occurrence of phosphate in several States.

542 **Merriam** (John C.). A contribution to the geology of the John Day basin [Oregon].

Univ. of Cal. Dept. of Geol., Bull., vol. 2, pp. 269–314, pls. 6–8, fig. 1, 1901.

Gives a sketch of previous explorations and literature of the region, and describes the classification, character, occurrence, relations, and faunas of the Cretaceous, Tertiary, and Pleistocene strata.

543 —— A geological section through the John Day basin [Oregon].

Abstracts: Jour. Geol., vol. 9, pp. 71–72, 1901; Geol. Soc. Am., Bull., vol. 12, pp. 496–497, 1901.

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544 **Merrill** (George P.). The Department of Geology in the National Museum.

Am. Geol., vol. 28, pp. 107–123, pls. 10–14, 1901.

Gives an account of the methods employed in caring for and rendering available to students the materials in charge of this department of the Museum, and in displaying the same for the benefit of the public.

544a —— On a stony meteorite which fell near Felix, Perry County, Alabama, May 15, 1901.

U. S. Nat. Mus., Proc., vol. 24, pp. 193–198, pls. xiii–xiv, 1901.

545 —— Guide to the study of the collections in the section of applied geology—the nonmetallic minerals [U. S. National Museum].

U. S. Nat. Mus., Ann. Rept. for 1899, pp. 156–483, pls. 1–30, figs. 1–13, 1901.

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546 —— and **Stokes** (H. N.). A new stony meteorite from Allegan, Michigan, and a new iron meteorite from Mart, Texas.

Wash. Acad. Sci., Proc., vol. 2, pp. 41–68, 6 pls., 1900.

Describes the occurrence, characters, and chemical composition of the material.

547 **Miller** (Arthur M.). Preglacial drainage in southwestern Ohio.

Science, new ser., vol. 14, pp. 534–535, 1 fig., 1901.

548 **Miller** (B. L.). Geology of Marion County [Iowa].

Iowa Geol. Surv., vol. 11, pp. 130–197, pl. 5, figs. 9–12 and map, 1901.

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549 **Miller** (Gerrit S., jr.). Preliminary list of mammals of New York.

N. Y. State Mus., 53rd Ann. Rept., vol. 1, pp. 267–390, 1901.

Contains list of fossil species.

550 **Miller** (Willet G.). On some newly discovered areas of nepheline syenite in central Canada.

Am. Geol., vol. 27, pp. 21–25, 1901.

Describes character and occurrence in Ontario.

551 **Miller** (Willet G.). Iron ores of Nipissing district [Ontario].
Ontario Bureau of Mines, Rept. for 1901, pp. 160–180, pls. 21–24, 2 figs., 1901.
Describes the physiography of the region and the occurrence and character of the iron ores in Huronian rocks.

552 —— The iron ore fields of Ontario.
Can. Mg. Rev., vol. 20, pp. 151–158, 3 figs., 1901; Can. Mg. Jour., vol. 4, pp. 265–283, 3 figs., 1901.
Contains notes on the occurrence and character of iron ore deposits in Ontario.

553 **Miller** (W. W. jr.). Analysis of emery from Virginia.
Abstract: Am. Geol., vol. 27, pp. 314–315 (⅓ p.), 1901.

554 —— Examination of sandstone from Augusta County, Virginia.
Abstract: Am. Geol., vol. 27, p. 315 (¼ p.), 1901.

555 —— Analysis of smithsonite from Arkansas.
Abstract: Am. Geol., vol 27, p. 315 (¼ p.), 1901.

556 **Montgomery** (Thomas H.). Missing links.
Sci. Am. Suppl., vol. 52, pp. 21732–21734, 1901.
Abstract of lecture delivered at the Wagner Institute, Philadelphia, Pennsylvania.

557 **Morganroth** (L. C.). The caves of Huntington County Pennsylvania.
Eng. and Mg. Jour., vol. 71, p. 664 (½ p.), 1901.
Describes the character of the cave.

558 **Moses** (A. J.). Mineralogical notes.
Am. Jour. Sci., 4th ser., vol. 12, pp. 98–106, figs. 1–6, 1901.
Describes crystallographic characters of pectolite, atacamite, realgar, vesuvianite, chrysoberyl, and pyroxene.

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559 **Nansen** (Fridtjof). The Norwegian North Polar expedition, 1893–1896.
Scientific results, vols. 1–2, 1901. Longmans, Green & Co., London, New York, 1901.
Review: Jour. Geol., vol. 9, pp. 273–275, 1901.

560 **Nason** (Frank L.). On the presence of a limestone conglomerate in the lead region of St. François County, Missouri.
Am. Jour. Sci., 4th ser., vol. 11, p. 396 (⅓ p.), 1901.
Brief note announcing discovery of limestone conglomerate between the St. Joseph or Bonne Terre limestone and the Potosi in Missouri.

561 —— The geological relations and the age of the St. Joseph and Potosi limestones of St. François County, Missouri.
Am. Jour. Sci., 4th ser., vol. 12, pp. 358–361, 1901.
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562 **Nason** (Frank L.). The origin of vein cavities.
Eng. and Mg. Jour., vol. 71, pp. 177–179, 209–210, 1901.
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563 **Nevins** (J. N.). Roofing slate quarries of Washington County [New York].
N. Y. State Mus., 53d Ann. Rept., vol. 1, pp. r135–r150, pls. 26–37, 1901.
Describes the slates of the various quarries.

564 —— Emery mines of Westchester County [New York].
N. Y. State Mus., 53d Ann. Rept., vol. 1, pp. r151–r154, pls. 38–41, 1901.

565 **Newland** (D. H.). The serpentines of Manhattan Island and vicinity and their accompanying minerals.
School of Mines Quart., vol. 22, pp. 307–317, 399–410, figs. 1–4, 1901.
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566 **Nichols** (Henry W.). Nitrates in cave earths.
Jour. Geol., vol. 9, pp. 236–243, 1901.
Abstract: Am. Geol., vol. 28, p. 58 (½ p.), 1901.
Reviews paper by William H. Hess on the same subject, gives a number of analyses of soil, limestone, and cave earth and discusses the origin of the nitrates.

567 **Nicolson** (J. T.), **Adams** (Frank D.), and. An experimental investigation into the flow of marble.
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568 **Norton** (William Harmon). Geology of Cedar County [Iowa].
Iowa Geol. Surv., vol 11, pp. 282–396, pls. 7–12, figs. 16–27, and maps, 1901.
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569 —— The relation of physical geography to other science subjects.
Science, new ser., vol 14, pp. 205–210, 1901.

570 **Nutter** (Edward Hoit). Sketch of the geology of the Salinas Valley, California.
Jour. Geol., vol. 9, pp. 330–336, 8 figs., 1901.
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571 **Nylander** (Olof O.). Shells of the marl deposits of Aroostook County, Maine, as compared with the living forms in the same locality.
Nautilus, vol. 14, pp. 101–104, 1901.
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572 **Obalski** (J.). Notes on the magnetic iron sand of the north shore of the St. Lawrence [Canada].
Can. Mg. Rev., vol. 20, pp. 34–37, 1 fig., 1901.
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573 **Ordoñez** (Ezequiel). Las rhyolitas de Mexico. I.
Mexico Inst. Geol., Bull. No. 14, 75 pp., 5 pls., 1900.
Bull. No. 15, 76 pp., pls. 1–11, 1901.
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574 —— La industria minera en Mexico.
Ciencia y Arte, Mexico, 19 pp., 1901. (Not seen.)

575 —— The mining district of Pachuca, Mexico.
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Am. Nat., vol. 35, pp. 139–142, 1901.
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577 **Orton** (Edward). Petroleum and natural gas in New York.
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578 **Osborn** (Henry Fairfield). The recent progress of vertebrate paleontology in America.
Science, new ser., vol. 13, pp. 45–49, 1901.
Abstract of lecture delivered at Trinity College, Hartford, Conn.

579 —— Recent zoo-paleontology.
Science, new ser., vol. 14, pp. 330–331, 1901.
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580 —— [Review of "Diplodocus Marsh. Its osteology, taxonomy, and probable habits, with the restoration of the skeleton" by J. B. Hatcher.]
Science, new ser., vol. 14, pp. 531–532, 1901.

581 —— Recent zoo-paleontology.
Science, new ser., vol. 14, pp. 699–700, 1901.
Reviews Wortman's work on the Carnivora and Gidley's work on Pleistocene horses.

582 —— Des méthodes précises mises actuellement en œuvere dans l'étude des vertébrés fossiles des États-Unis d'Amérique.
Int. Cong. Geol., Compte Rendu, viii session, pp. 353–356, pls. i–ii, 1901.

583 **Osborn** (Henry Fairfield). Corrélation des horizons de mammifères Tertiaires en Europe et en Amérique.
Int. Cong. Geol., Compte Rendu, viii session, pp. 357–363, 1901.

584 —— Systematic revision of the American Eocene primates and of the rodent family Myxodectidæ.
Abstract: N. Y. Acad. Sci., Annals, vol. 14, p. 111, 1901.

585 —— and **Granger** (Walter). Fore and hind limbs of Sauropoda from the Bone Cabin quarry [Wyoming].
Am. Mus. Nat. Hist., Bull., vol. 14, pp. 199–208, figs. 1–6, 1901.

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585a **Palache** (Charles), **Lawson** (Andrew C.), and. The Berkeley Hills [California]. A detail of Coast Range geology.
See Lawson (A. C.) and Palache (C.), 485a.

586 **Parkinson** (John). The hollow spherulites of the Yellowstone and Great Britain.
Lond. Geol. Soc., Quart. Jour., vol. 57, pp. 211–225, pl. 8, figs. 1–4, 1901.
Describes the author's observations in the Yellowstone region and discusses the origin of spherulites.

587 —— Some lake basins in Alberta and British Columbia.
Geol. Mag., new ser., dec. iv, vol. 8, pp. 97–101, pl. 4, 1901.
Describes the physiography of the region and the character of the lake basins.

588 **Patton** (H. B.). Abstracts of papers read before Section E of the American Association for the Advancement of Science, August 26–29, 1901.
Science, new ser., vol. 14, pp. 794–800, 1901.

589 **Pearson** (H. W.). Oscillations in the sea-level.
Geol Mag., new ser., vol. 8, pp. 167–174, 223–231, 253–265, 1901
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590 **Peck** (F. B.). Preliminary notes on the occurrence of serpentine and talc at Easton, Pa.
N. Y. Acad. Sci., Annals, vol. 13, pp. 419–430, pl 16, figs. 4–5, 1901.
Describes the general geology and structure of the region and the occurrence of the crystalline rocks and the alteration products.

591 **Peckham** (Herbert E.). On the bituminous deposits situated at the south and east of Cardenas, Cuba.
Am. Jour. Sci., 4th ser., vol. 12, pp. 33–41, figs. 1–2, 1901.
Describes the occurrence and extent of these bituminous deposits.

592 **Peckham** (S. F.). [Remarks on paper by Herbert E. Peckham on the bituminous deposits near Cardenas, Cuba.]
Am. Jour. Sci., 4th ser., vol. 12, p. 41 (½ p.), 1901.

593 **Penfield** (Samuel L.). On the chemical composition of childrenite.
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594 —— On the chemical composition of amblygonite.
Yale Bicentennial publications. Cont. to Mineral. and Petrog., pp. 121–123, 1901. (From Am. Jour. Sci., vol. 18, pp. 295–301, 1879.)

595 —— On spangolite, a new copper mineral.
Yale Bicentennial publications. Cont. to Mineral. and Petrog., pp. 168–175, 1901. (From Am. Jour. Sci., vol. 39, pp. 370–378, 1890.)

596 —— On pearcite, a sulpharsenite of silver.
Yale Bicentennial publications. Cont. to Mineral. and Petrog., pp. 252–260, 1901. (From Am. Jour. Sci., vol. 2, pp. 17–20, 1896.)

597 —— On the chemical composition of hamlinite and its occurrence with bertrandite at Oxford County, Maine.
Yale Bicentennial publications. Cont. to Mineral. and Petrog., pp. 287–290, 1901. (From Am. Jour. Sci., vol. 4, pp. 313–316, 1897.)

598 —— and **Foote** (H. W.). On bixbyite, a new mineral.
Yale Bicentennial publications. Cont. to Mineral. and Petrog., pp. 283–286, 1901. (From Am. Jour. Sci., vol. 4, pp. 105–107, 1897.)

599 —— —— On clinohedrite, a new mineral from Franklin, N. J.
Yale Bicentennial publications. Cont. to Mineral. and Petrog., pp. 291–296, 1901. (From Am. Jour. Sci., vol. 5, pp. 289–293, 1898.)

600 —— and **Ford** (W. E.). On calaverite.
Am. Jour. Sci., 4th ser., vol. 12, pp. 225–245, figs. 1–30, 1901.
Describes occurrence and crystallographic characters of the material.

601 —— and **Pirsson** (L. V.). Contributions to mineralogy and petrography, from the laboratories of the Sheffield Scientific School of Yale University.
Yale Bicentennial publications. August, 1901, 482 pp., Charles Scribner's Sons, New York.
Abstracts: Am. Geol., vol. 28, pp. 322–323, 1901. Am. Jour. Sci., 4th ser., vol. 12, pp. 398 (½ p.), 1901.

602 —— and **Pratt** (J. H.). On the occurrence of thaumasite at West Paterson, New Jersey.
Yale Bicentennial publications. Cont. to Mineral. and Petrog., pp. 246–251, 1901. (From Am. Jour. Sci., vol. 1, pp. 229–233, 1896.)

603 —— and **Warren** (C. H.). Some new minerals from the zinc mines at Franklin, N. J., and note concerning the chemical composition of ganomalite.
Yale Bicentennial publications. Cont. to Mineral. and Petrog., pp. 325–342, 1901. (From Am. Jour. Sci., vol. 8, pp. 339–353, 1899.)

604 **Penhallow** (D. P.). Notes on the North American species of Dadoxylon, with special reference to type material in the collections of the Peter Redpath Museum, McGill College

Can. Roy. Soc., Proc. & Trans., 2nd ser., vol. 6, sect. 4, pp. 51–97, figs. 1–18, 1900.

605 —— A decade of North American Paleobotany, 1890–1900.

Science, new ser., vol. 13, pp. 161–176, 1901.

Presidential address before the Society of Plant Morphology and Physiology.

606 —— [Review of "Studies in fossil botany," by D. H. Scott.]

Science, new ser., vol. 13, pp. 386–389, 1901.

607 —— [Review of "The Mesozoic flora of the United States," by L. F. Ward et al.]

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608 **Phillips** (William Battle). Texas petroleum.

Texas Univ. Min. Surv., Bull. No. 1, pp. 1–102, 1901.

Describes the nature and origin of petroleum and the oil and gas-bearing horizons of Texas.

609 —— The Beaumont oil field, Texas.

Eng. & Mg. Jour., vol. 71, pp. 175–176, 1901.

Contains notes on the geology of the region.

610 —— The zinc-lead deposits of southwest Arkansas.

Eng. and Mg. Jour., vol. 71, pp. 431–432, 1901.

Contains brief notes on the character and occurrence of the ore

611 —— The bat guano caves of Texas.

Mines and Minerals, vol. 21, pp. 440–442, 6 figs., 1901.

Describes occurrence and chemical character of the material.

612 **Pierce** (S. J.). The Cleveland water-supply tunnel [Ohio].

Am. Geol., vol. 28, pp. 380–385, 1901.

Describes the quicksands and clays and other material penetrated in driving this tunnel.

613 **Pilsbry** (Henry A.). Crustacea of the Cretaceous formation of New Jersey.

Phil. Acad. Nat. Sci., Proc., 1901, pp. 111–118, pl. 1, 1901.

614 **Pirsson** (Louis V.). [Review of "Geological and Natural History of Minnesota, Vol. V;" and "Étude minéralogique et petrographique des Roches gabbroïques de l'État de Minnesota, États-Unis, et plus spécialement des Anorthosites," by A. N. Winchell.]

Am. Jour. Sci., 4th ser., vol. 11, pp. 88–89, 1901.

615 **Pirsson** (Louis V.). On mordenite.

Yale Bicentennial publications. Cont. to Mineral. and Petrog., pp. 176–182, 1901. (from Am. Jour. Sci., vol. 40, pp. 232–237, 1890)

616 —— On the petrography of Square Butte in the Highwood Mountains of Montana.

Yale Bicentennial publications. Cont. to Mineral. and Petrog., pp. 415–435, 1901. (from Geol. Soc. Am., Bull., vol. 6, pp. 389–422, 1895)

617 —— Petrography of the rocks of Yogo Peak [Montana].

Yale Bicentennial publications. Cont. to Mineral. and Petrog., pp. 436–456, 1901. (abstract from U. S. Geol. Surv., 20th Ann. Rept., pt. 111, pp. 471–488, 1900)

617a —— **Penfield** (Samuel L.) and. Contributions to mineralogy and petrography, from the laboratories of the Sheffield Scientific School of Yale University.

See Penfield (S. L.) and Pirsson (L. V.), 601.

618 —— **Weed** (Walter H.) and. Missourite, a new leucite rock from the Highwood Mountains of Montana.

See Weed (Walter H.) and Pirsson (Louis V.), 799.

619 —— —— Geology of the Shonkin sag and Palisade Butte laccoliths in the Highwood Mountains of Montana.

See Weed (W. H.) and Pirsson (L. V.), 798.

620 **Pompecky** (J. F.). Jura-fossilien aus Alaska.

Verhandl. Kais. Russ., Mineralog. Gesell., St. Petersbourg, ser. 2, Band. 38, No. 1, 1900. (Not seen.)

Abstract: Am. Nat., vol. 35, pp. 420–421, 1901.

621 **Pratt** (Joseph Hyde). A peculiar iron of supposed meteoric origin from Davidson County, North Carolina.

Elisha Mitchell Sci. Soc., Jour., 17th year, pt. 2, pp. 21–26, 1901.

Describes character of the material and gives chemical analysis.

622 —— The occurrence and distribution of corundum in the United States.

U. S. Geol. Surv., Bull. No. 180, pp. 1–98, pls. i–xiv, figs. 1–14, 1901.

Describes the modes of occurrence and distribution of corundum and the corundum localities in the United States.

623 —— On northupite; pirssonite, a new mineral; gay-lussite and hanksite from Borax Lake, San Bernardino County, California.

Yale Bicentennial publications. Cont. to Mineral. and Petrog., pp. 261–274, 1901. (from Am. Jour. Sci., vol. 2, pp. 128–135, 1896)

624 —— and **Foote** (H. W.). On wellsite, a new material.

Yale Bicentennial publications. Cont. to Mineral. and Petrog., pp. 275–282, 1901. (from Am. Jour. Sci., vol. 3, pp. 443–448, 1897)

625 **Pratt** (Joseph Hyde) and **Penfield** (S. L.). On the occurrence of thaumasite at West Paterson, New Jersey.
See Penfield (S. L.) and Pratt (J. H.), 602.

626 **Preston** (C. H.). Prof. W. H. Barris.
Am. Geol., vol. 28, pp. 358-361, pl. 33, 1901.
Gives a sketch of his life and work on the paleontology of Iowa.

627 **Price** (J. A.) and **Shaaf** (Albert). Spy Run and Poinsett lake bottoms [Indiana].
Ind. Acad. Sci., Proc. for 1900, pp. 179-181, 1901.
Describes glacial phenomena.

628 —— —— Abandoned meanders of Spy Run Creek [Indiana].
Ind. Acad. Sci., Proc. for 1900, pp. 181-184, 1 fig., 1901.
Describes its drainage modifications.

629 **Prosser** (Charles S.). The classification of the Waverly series of Central Ohio.
Jour. Geol., vol. 9, pp. 205-231, figs. 1-4, 1901.
Reviews the various classifications of this series that have been published, describes the character and occurrence of the strata, and gives the author's classification.

630 —— [On the use of the term Bedford limestone.]
Jour. Geol., vol. 9, pp. 270-272, 1901.
Reviews an article by C. E. Siebenthal on the same subject and considers the name Bedford as applied in Ohio should be accepted.

631 —— The Paleozoic formations of Allegany County, Maryland.
Jour. Geol., vol. 9, pp. 409-429, figs. 1-4, 1901.
Describes the character and occurrence of the various Paleozoic formations and discusses their probable correlations with New York and Pennsylvanian formations.

632 —— Names for the formations of the Ohio Coal Measures.
Am. Jour. Sci., 4th ser., vol. 11, pp. 191-199, 1901.
Reviews previous classification and nomenclature of the Coal Measures of Pennsylvania and West Virginia and presents a section and the classification of the Coal Measures of Maryland, which has been adopted for the Ohio Coal Measures.

633 **Purdue** (A. H.). Valleys of solution in northern Arkansas.
Jour. Geol., vol. 9, pp. 47-50, figs. 1-2, 1901.
Describes the character and occurrence of these valleys and discusses their origin.

634 —— Illustrated note on a miniature overthrust fault and anticline.
Jour. Geol., vol. 9, pp. 341-342, 1 fig., 1901.
Describes a miniature anticline passing into a reversed fault at Ozark, Ark.

635 —— Physiography of the Boston Mountains, Arkansas.
Jour. Geol., vol. 9, pp. 694-701, figs. 1-2, 1901.
Abstract: Sci. Am. Suppl., vol. 52, p. 21505, 1901.
Describes the structural and topographic features of the region.

636 **Purington** (Chester Wells). Economic geology. La Plata Folio, Colo.

U. S. Geol. Surv., Geol. Atlas of U. S., Folio No. 60, 1899.

Describes the vein systems, the occurrence of gold and silver ores, the placer deposits, and the occurrence of coal.

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637 **Queneau** (A. J.). The grain of igneous rocks.

Abstract: N. Y. Acad. Sci., Annals, vol. 14, p. 163, 1901.

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638 **Randolph** (Beverley S.). [In discussion of paper by Charles Catletton, "Coal outcrops."]

Am. Inst. Mg. Engrs., Trans., vol. 30, pp. 1005–1006, 1901.

639 **Ransome** (Frederick Leslie). A report on the economic geology of the Silverton quadrangle, Colorado.

U. S. Geol. Surv., Bull. No. 182, pp. 1–265, pls. i–xvi, figs. 1–23, 1901.

Describes the lode fissures, the characters of the ores and of the stocks or masses, and the origin of the ore deposits. Includes detailed descriptions of special areas.

640 —— A peculiar clastic dike near Ouray, Colorado, and its associated deposit of silver ore.

Am. Inst. Mg. Engrs., Trans., vol. 30, pp. 227–236, figs. 1–2, 1901.

Describes the occurrence, character, and origin of the dike and of the associated ore body.

641 **Raymond** (R. W.). Recent contributions to the science of ore deposits.

Min. Ind. for 1900, pp. 753–762, 1901.

Gives a review and summaries of recent important papers on the origin of ore deposits.

642 **Reid** (Harry Fielding). De la progression des glaciers, leur stratification, et leurs veines bleues.

Int. Cong. Geol., Compte Rendu, viii session, pp. 749–755, 1901

643 —— The variations of glaciers, VI.

Jour. Geol., vol. 9, pp. 250–254, 1901.

This paper comprises a summary of the Fifth Annual report of the International Committee on glaciers.

644 —— [Review of "Les variations de Longueur des Glaciers dans les Regions Artique et Boriales," by Charles Rabot.]

Science, new ser., vol. 14, pp. 928–930, 1901.

645 **Richards** (Joseph W.). "Mohawkite."

Am. Jour. Sci., 4th ser., vol. 11, pp. 457–458, 1901.

Abstract: Am. Geol., vol. 28, pp. 58 (10–11), 1901.

Gives results of the author's chemical studies, which prove the existence of the species termed mohawkite and of another species for which the name ledouxite is proposed.

646 **Rickard** (Forbes). Notes on Nome, and the outlook for vein mining in that district [Alaska].

Eng. and Mg. Jour., vol. 71, pp. 275–276, 1 fig., 1901.

Contains notes on the geology of the region and the occurrence of gold.

647 **Rickard** (T. A.). The Cripple Creek volcano [Colorado].

Am. Inst. Mg. Engrs., Trans., vol. 30, pp. 367–403, figs. 1–2, 1901.

Gives an account of the various stages of eruption in this volcano and compares it with volcanos in other regions.

648 —— The telluride ores of Cripple Creek [Colorado] and Kalgoorlie [Australia].

Am. Inst. Mg. Engrs., Trans., vol. 30, pp. 708–718, 1901.

Describes the characteristics of the ores of these regions.

649 **Ries** (Heinrich). Theodore Greely White.

Am. Geol., vol. 28, pp. 269–270, with portrait, 1901.

Gives a brief sketch of his life and work, and a list of publications.

650 **Riggs** (Elmer S.). The Dinosaur beds of the Grand River valley of Colorado.

Field Col. Mus., Geol. ser., vol. 1, pp. 267–274, pls. 34–39, 1901.

Describes the general character of the Cretaceous, Jurassic, and Triassic strata and the occurrence of vertebrate remains.

651 —— The fore leg and pectoral girdle of Morosaurus. With a note on the genus Camarosaurus.

Field Col. Mus., Geol. ser., vol. 1, pp. 275–281, pls. 40–42, 1901.

652 —— The largest known dinosaur.

Science, new ser., vol. 13, pp. 549–550, 1901.

Contains brief description of the skeleton obtained by a recent expedition of the Field Columbian Museum.

653 **Ritter** (Wm. E.). Some observations bearing on the probable subsidence during recent geologic times of the Island of Santa Catalina off the coast of southern California.

Science, new ser., vol. 14, pp. 575–577, 1901.

654 **Robinson** (H. H.). On octohedrite and brookite, from Brindletown, North Carolina.

Am. Jour. Sci., 4th ser., vol. 12, pp. 180–184, figs. 1–6, 1901.

Describes occurrence and crystallographic characters of the minerals.

655 **Rogers** (Austin F.). Mineralogical notes, No. 2.

Am. Jour. Sci., 4th ser., vol. 12, pp. 42–48, figs. 1–8, 1901.

Describes crystallographic characters of calcite, galena, pyrite, topaz, leadhillite, iivarite, caledonite, barite, and celestite.

656 —— The Pottawatomie and Douglas formations along the Kansas River.

Kan. Univ. Quart., vol. 9, pp. 234–254, 1900.

Gives lists of fossils from various localities.

657 **Ropes** (Leverett S.). [Corundum of North Carolina.]
Min. Ind., 1899, pp. 12-14, 1900.
Notes on occurrence.

658 **Rowley** (R. R.). Two new genera and some new species of fossils from the Upper Paleozoic rocks of Missouri.
Am. Geol., vol. 27, pp. 343-355, pl. 28, 1901.
Describes species of two little known groups of blastoids.

659 **Ruedemann** (Rudolf). Hudson River beds near Albany and their taxonomic equivalents.
N. Y. State Mus., Bull. No. 42, pp. 489-587, pls. 1-2, figs. 1-5, 1901.
Abstract: Am. Geol., vol. 27, pp. 377-378, 1901.
Reviews previous work on these strata. Describes the lithologic and faunal characters at various localities in the region and discusses the geologic structure and correlation of the beds. Describes the characters of new species of fossils collected.

660 —— Trenton conglomerate of Rysedorph Hill, Rensselaer County, N. Y., and its fauna.
N. Y. State Mus., Bull. 49, pp. 3-114, pls. A-B and 1-7, 1901.
Describes the stratigraphic relations and characters of the fauna.

661 **Russell** (Israel C.). Geology and water resources of Nez Perce County, Idaho. Part I.
U. S. Geol. Surv., Water-Supply and Irrigation Papers, No. 53, pp. 1-85, pls. i-x, figs. 1-4, 1901. Abstract: Am. Geol., vol. 28, pp. 319-321, 1901.
Describes the pre-Tertiary terranes, the Columbia lava, the soils and the physiography of the region.

662 —— Geology and water resources of Nez Perce County, Idaho. Part II.
U. S. Geol. Surv., Water-Supply and Irrigation Papers, No. 54, pp. 95-141, figs. 5-14, 1901.
Describes the character and occurrence of the water supply, building stones, and lignite. Includes a bibliography of artesian waters and a note concerning Portland cement.

663 **Rutland** (Joshua). Mammals and reptiles; or what was the Ice ages?
Sci. Am. Suppl., vol. 51, pp. 21032-21033, 1901.
Describes their occurrence and characters in geologic times.

664 **Rutley** (Frank). Mineralogy.
12th ed., 240 pp., 1900. Thomas Murby, London.
Review: Am. Jour. Sci., 4th ser., vol. 11, p. 921 (½ p.), 1901.

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665 **Safford** (J. M.). Classification of the geological formations of Tennessee.
Geol. Soc. Am., Bull., vol. 13, pp. 10-14, 1901.
Gives in tabular form a list of the geological formations of Tennessee and includes brief notes regarding them.

666 **Safford** (J. M.). Horizons of phosphate rocks in Tennessee.
Geol. Soc. Am., Bull., vol. 13, pp. 14–15, 1901.
Describes the geologic relations of the various phosphate deposits.

667 **Salisbury** (Rollin D.) [Reviews of "The Norwegian Polar Expedition, 1893 to 1896. Scientific Results, Vol. I," and "The Pleistocene geology of the South Central Sierra Nevada, with especial reference to the origin of the Yosemite Valley," by H. W. Turner.]
Jour. Geol., vol 9, pp. 87–91, 1901.

668 —— [Reviews of "Handbuch der Seenkunde, allgemeine Limnologie," by F. A. Forel: "A preliminary report on the Artesian basins of Wyoming," by Wilbur C. Knight; and "Die vierte Eiszeit im Bereiche der Alpen," by Albrecht Penck.]
Jour. Geol., vol. 9, pp. 199–202, 1901.

669 —— [Review of "Glacial sculpture of the Bighorn Mountains, Wyoming," by F. E. Matthes.]
Jour. Geol., vol. 9, pp. 465–466, 1901.

670 —— Glacial work in the Western mountains in 1901.
Jour. Geol., vol. 9, pp. 718–731, 1901.
Describes the results of the work of several parties of students in various parts of western United States.

671 **Sardeson** (Frederick W.). Problem of the Monticuliporoidea. I.
Jour. Geol., vol. 9, pp. 1–27, pl. A. and fig. 1, 1901.
Describes the characters of various species of Trepostomata and discusses their affinities.

672 —— Problem of the Monticuliporidea. II.
Jour. Geol., vol. 9, pp. 149–173, pl. B, fig. 2, 1901.
Describes the general characters of various species of Cryptostomata and discusses their affinities.

673 —— Note on the western Tertiary.
Science, new ser., vol. 13, pp. 868–869, 1901.
Contains notes on the occurrence of fossils as indicating the mode of formation of the strata.

674 —— Fossils in the St. Peter sandstone.
Minn. Acad. Nat. Sci., Bull., vol. 3, pp. 318–319, 1901.

675 —— Paleozoic fossils in the drift [Minnesota].
Minn. Acad. Nat. Sci., Bull., vol. 3, pp. 317–318, 1901.

676 —— The lower Silurian formations of Wisconsin and Minnesota compared.
Minn. Acad. Nat. Sci., Bull., vol. 3, pp. 319–326, fig. 8, 1901.

677 **Sardeson** (Frederick W.). The range and distribution of the lower Silurian fauna of Minnesota, with descriptions of some new species.

Minn. Acad. Nat. Sci., Bull., vol. 3, pp. 326–343, 1901.

678 **Sarle** (Clifton J.). Reef structures in Clinton and Niagara strata of western New York.

Am. Geol., vol. 28, pp. 282–299, pls. 27–31, 1901.

Describes occurrence of irregular, hardened masses in the limestone and discusses their origin. Describes similar occurrences in other geologic horizons.

679 **Schiotz** (O. E.). Results of the pendulum observations and some remarks on the constitution of the earth's crust.

Nansen's Norwegian North Polar expedition. Scientific results, vol. 2, viii, pp. 1–90, 1901.

680 **Scholz** (C.). [In discussion of paper by Charles Catlett on "Coal outcrops."]

Am. Inst. Mg. Engrs., Trans., vol. 30, pp. 1107–1109, 1901.

681 **Schrader** (F. C.) and **Brooks** (Alfred H.). Some notes on the Nome gold region of Alaska.

Am. Inst. Mg. Engrs., Trans., vol. 30, pp. 236–247, figs. 1–3, 1901.

Describes the topography of the region, the occurrence of the placers, and the origin of the beach placers.

682 **Schuchert** (Charles). On the Helderbergian fossils near Montreal, Canada.

Am. Geol., vol. 27, pp. 245–253, figs. A–D, 1901.

Contains notes on the fossils and probable correlations of the St. Helens island faunas of New York. Figures two new species.

683 **Scott** (Dunkinfield Henry). Studies on fossil botany.

The Macmillan Co., N. Y., 533 pp., 1900.

Abstract: Am. Nat., vol. 35, pp. 73–77, 1901.

684 **Scott** (W. B.). Historical geology.

Sci. Am. Suppl., vol. 52, pp. 21352-21353, 1901.

Abstract of lecture delivered at the Wagner Institute, Philadelphia, Pa.

685 —— Earth carrying.

Sci. Am. Suppl., vol. 52, p. 21456, 1901.

Abstract of lecture delivered at the Wagner Institute, Philadelphia, Pa.

686 **Seeley** (Henry M.). Sketch of the life and work of Augustus Wing.

Am. Geol., vol. 28, pp. 1–8, pl. 1, 1901.

Describes the life of Augustus Wing and his work on the geology of Vermont.

687 **Seeley** (Henry M.). The geology of Vermont.
The Vermonter, vol. 5, pp. 53–67, Feb., 1901. (Not seen.)

688 **Sellards** (E. H.). Permian plants. Taeniopteris of the Permian of Kansas.
Kan. Univ. Quart., vol. 10, pp. 1–12, pls. 1–4, 1901.

689 —— Fossil plants in the Permian of Kansas.
Kan. Acad. Sci., Trans., vol. 17, pp. 208–209, 1901.
Describes occurrence of the plant remains at various localities.

690 **Shaaf** (Albert), **Price** (J. A.) and. Spy Run and Poinsett lake bottoms.
See Price (J. A.) and Shaaf (A.), 627.

691 —— Abandoned meanders of Spy Run Creek [Indiana].
See Price (J. A.) and Shaaf (A.), 628.

692 **Shaler** (N. S.). Broad valleys of the Cordilleras.
Geol. Soc. Am., Bull., vol. 12, pp. 271–300, 1901.
Discusses the origin and development of these valleys and the bearing of the evidence on the orographic features of the region.

693 **Shattuck** (George Burbank). The Pleistocene problem of the North Atlantic Coastal plain.
John Hopkins Univ., Circular No. 152, pp. 69–75, 1901.
Am. Geol., vol. 28, pp. 87–107, 1901.
Reviews the opinions of various writers on these problems and gives the author's conclusions.

694 —— Apparent unconformities during periods of continuous sedimentation.
Abstract: Science, new ser., vol. 13, pp. 99–100, 1901.

695 **Sheldon** (J. M. Arms). Concretions from the Champlain clays of the Connecticut valley.
45 pp., 1900. (Not seen.) Boston, Mass.
Abstract: Am. Jour. Sci., 4th ser., vol. 11, p. 397 ($\frac{1}{3}$ p.), 1901.

696 **Shimek** (B.). Recent decline in the level of Lake Nicaragua.
Am. Geol., vol. 28, pp. 396–398, 1901.
Refers to a paper published in 1896 on the same subject.

697 —— The loess of Iowa City and vicinity [Iowa].
Iowa State Univ., Lab. Nat. Hist., Bull., vol. 5, pp. 195–212, 1901.
Am. Geol., vol. 28, pp. 344–358, 1901.
Gives list of loess and recent fossils with notes on some of the species.

698 **Siebenthal** (C. E.). On the use of the term Bedford limestone.
Jour. Geol., vol. 9, pp. 234–235, 1901.
Discusses the use of the name in Ohio and Indiana and considers the Bedford of Indiana has priority.

699 **Siebenthal** (C. E.). [Review of "Twenty-fifth Annual Report, Department of Geology and Natural Resources of Indiana."]

Jour. Geol., vol. 9, pp. 354–356, 1901.

700 —— [Review of "Texas petroleum" by William Battle Phillips.]

Jour. Geol., vol. 9, pp. 637–638, 1901.

701 —— The Silver Creek hydraulic limestone of southeastern Indiana.

Ind. Dept. of Geol. and Nat. Res., 25th Ann. Rept., pp. 331–389, pls. 13–14, figs. 71–72, 1901.

Reviews the geologic literature regarding the region, describes the stratigraphic and paleontologic features and nomenclature of the Devonian formations, and gives an account of the economic uses of the limestone.

702 **Simonds** (Frederic W.). The minerals and mineral localities of Texas.

Abstract: Science, new ser., vol. 14, p. 797, 1901.

Gives an account of the preparation of a list of Texas minerals and localities.

703 **Sinclair** (William J.). The discovery of a new fossil tapir in Oregon.

Jour. Geol., vol. 9, pp. 702–707, fig. 1, 1901.

Describes Protapirus robustus n. sp. from the John Day beds.

704 **Slosson** (E. E.), **Knight** (W. C.) and. Alkali lakes and deposits [Wyoming].

See Knight (W. C.) and Slosson (E. E.), 451.

705 —— The Dutton, Rattlesnake, Arago, Oil Mountain, and Powder River oil fields [Wyoming].

See Knight (W. C.) and Slosson (E. E.), 450.

706 **Smith** (Alva J.). The Americus limestone.

Kans. Acad. Sci., Trans., vol. 17, pp. 189–190, pls. 15–17, 1901.

Describes its distribution in Lyon County, Kansas, and its petrographic and faunal characters.

707 **Smith** (George Otis). A geological study of the Fox Islands, Maine.

Colby College, Bull., vol. 1, supplement, pp. 1–53, and geologic map, 1901.

Describes the character and occurrence of the sedimentary and igneous rocks and the geologic history of the islands.

708 —— Geology and water resources of a portion of Yakima County, Washington.

U. S. Geol. Surv., Water Supply and Irrigation Papers, No. 55, pp. 1–68, pls. i–vii, figs. 1–8, 1901.

Describes the geographic and geologic features of the region and the water resources.

709 **Smith** (George Otis) and **Willis** (Bailey). The Clealum iron ores, Washington.

Am. Inst. Mg. Engrs., Trans., vol. 30, pp. 356–366, 1 fig., 1901.

Describes the character, occurrence and origin of the ores and the general geologic and structural feature of the region.

710 **Smith** (James Perrin). The border line between the Paleozoic and Mesozoic in western America.

Jour. Geol., vol. 9, pp. 512–521, 1901.

Discusses briefly the criteria by which geologic time divisions of the line between this Paleozoic and Mesozoic as influenced by the faunas of certain beds of Idaho and California and their relation to allied Asiatic and European faunas.

711 —— and **Weller** (Stuart). Prodromites, a new ammonite genus from the Lower Carboniferous.

Jour. Geol., vol. 9, pp. 255–268, pls. 6–8, 1901.

Discusses the occurrence of ammonites in upper Paleozoic rocks of the Mississippi Valley, and describes a new genus and two new species.

712 **Smock** (John C.). Administrative report. (New Jersey Geological Survey.)

N. J. Geol. Surv., Ann. Rept. for 1900, pp. xi–xl, 1901.

Gives an account of the work of the Survey for the year, and discusses the character and relations of the surface formations of southern New Jersey.

713 **Smyth** (C. H., jr.). Geology of the crystalline rocks in the vicinity of the St. Lawrence River.

N. Y. State Mus., 53d Ann. Rept., vol. 1, pp. r85–r104, pls. 13–24 and geologic map, 1901.

Describes the gneiss and associated rocks of the region.

714 **Sollas** (W. J.). Evolutional geology.

Smith. Inst., Ann. Rept. 1900, pp. 289–314, pl. 1, 1901.

715 **Spalding** (E. P.). The quicksilver mines of Brewster County, Texas.

Eng. & Mg. Jour., vol. 71, pp. 749–750, figs. 1–6, 1901.

Contains notes on the character and occurrence of the ore.

716 **Spencer** (Arthur C.). The iron ores of Santiago, Cuba.

Eng. & Mg. Jour., vol. 72, pp. 633–634, 6 figs., 1901.

Describes the character and geologic relations of the ore bodies.

717 —— The physiography of the Copper River basin, Alaska.

Abstract: Science, new ser., vol. 13, p. 189, 1901.

Contains abstract of paper read before the Geological Society of Washington.

718 —— See **Cross** (Whitman), 176.

719 **Spencer** (Joseph William Winthrop). On the geological and physical development of Antigua.

London Geol. Soc., Quart. Jour., vol. 57, pp. 490–505, and map, 1901.

720 **Spencer** (Joseph William Winthrop). On the geological and physical development of Guadelupe.

London Geol. Soc., Quart. Jour., vol. 57, pp. 506–519, 1901.

721 —— On the geological and physical development of Anguilla, St. Martin, St. Bartholomew, and Sombrero.

London Geol. Soc., Quart. Jour., vol. 57, pp. 520–533, 1901.

722 —— On the geological and physical development of the St. Christopher chain and Saba Banks.

London Geol. Soc., Quart. Jour., vol. 57, pp. 534–544, 1901.

723 **Spurr** (Josiah Edward). Origin and structure of the Basin ranges.

Geol. Soc. Am., Bull., vol. 12, pp. 217–270, pls. 20–25, 1901.

Abstract: Science, new ser., vol. 13, p. 98, 1901.

Describes the structural features of the ranges in the Great Basin region and discusses their origin.

724 —— Variations of texture in certain Tertiary igneous rocks of the Great Basin.

Jour. Geol., vol. 9, pp. 586–606, fig. 1, 1091.

Describes the character and occurrence of the variations of certain andesitic and rhyolitic rocks and gives chemical analyses.

725 **Stanton** (Timothy W.). [Report on Cretaceous fossils from the John Day Basin, Oregon.]

Univ. of Cal., Dept. of Geol., Bull., vol. 2, pp. 280–284, 1901.

Gives list of fossils with notes on some of the species and discusses the faunal relations.

726 —— Chondrodonta, a new genus of ostreiform mollusks from the Cretaceous, with descriptions of the genotpye and a new species.

U. S. Nat. Mus., Proc., vol. 24, pp. 301–307, pls. 25–26, 1901.

727 **Stearns** (Robert E. C.). Fossil land shells of the John Day region, with notes on related living species.

Wash. Acad. Sci., Proc., vol. 2, pp. 651–658, pl. 35, 1900.

727a —— The fossil fresh-water shells of the Colorado desert, their distribution, environment, and variation.

U. S. Nat. Mus., Proc., vol. 24, pp. 271–299, pls. xix, xxiv, 1901.

728 **Stevens** (E. A.). An occurrence of limburgite in the Cripple Creek district [Colorado].

Am. Inst. Mg. Engrs., Trans., vol. 30, pp. 759–764, figs. 1–4, 1901.

Describes the occurrence and character of this rock type.

729 **Stokes** (H. N.). On pyrite and marcasite.

U. S. Geol. Surv., Bull. No. 186, pp. 1–50, pl. 1, figs. 1–2, 1901; Am. Jour. Sci., 4th ser., vol. 12, pp. 414–420, 1901.

Describes the uncertainty of the methods of distinguishing pyrite and marcasite and a method for the quantitative determination of the minerals when in mixture, and discusses the relations of these sulphides to those of copper.

730 **Stokes** (N. H.), **Merrill** (George P.) and. A new stony meteorite from Allegan, Michigan, and a new iron meteorite from Mart, Texas.

See Merrill (George P.) and Stokes (H. N.), 546.

731 **Stose** (George W.). [Review of "Allegany County, Maryland."]

Science, new ser., vol. 14, pp. 181–182, 1901.

732 **Stone** (George H.). Note on the minerals associated with copper in parts of Arizona and New Mexico.

Abstracts: Science, new ser., vol. 14, pp. 796–797, 1901.
Sci. Am. Suppl., vol. 52, p. 21505, 1901.

733 —— Note on the extinct glaciers of New Mexico and Arizona.

Abstract: Science, new ser., vol. 14, p. 798, 1901.
Brief account of occurrence.

734 **Stretch** (R. H.). The Silverton mining district, Snohomish County, Washington.

Eng. and Mg. Jour., vol. 72, p. 105, 1901.
Describes briefly the occurrence of copper ores.

T.

735 **Taff** (Joseph A.). A comparison of the Ouachita and Arbuckle Mountain sections, Indian Territory.

Abstract: Science, new ser., vol. 13, pp. 271–272, 1901.
Briefly describes sections of Paleozoic rocks.

736 —— Colgate Folio—Indian Territory.

U. S. Geol. Surv., Geol. Atlas of U. S., Folio No. 74, 1901.
Describes the geographic and topographic features, the general geologic relations, the character and occurrence of the Carboniferous, Neocene and Pleistocene strata, and the occurrence of coal.

737 **Talmage** (J. E.). A recent fault slip, Ogden Canyon, Utah.

Science, new ser., vol. 13, p. 550, 1901.
Gives a brief account of the phenomena.

738 **Taylor** (F. B.). Glacial phenomena in eastern Ontario.

Abstract: Science, new ser., vol. 13, p. 138, 1901.

739 **Tays** (E. A. H.). Genesis of ore deposits.

Mg. and Sci. Press., vol. 83, pp. 142–143, 3 figs., 1901.
Discusses article by M. W. Alderson on the same subject.

740 **Tight** (W. G.). Pre-Glacial drainage in southwestern Ohio.

Science, new ser., vol. 14, pp. 775–776, 1901.
Discusses recent article by A. M. Miller on the same subject.

741 **Todd** (James E.). River action phenomena.

Geol. Soc. Am., Bull., vol. 12, pp. 486–490, 1901.
Discusses the variations in phenomena of river action in time of flood and the formation of silt and loess deposits.

742 **Todd** (James E.). Some problems of the Dakota artesian system.
Abstract: Science, new ser., vol. 14, p. 794, 1901.
Sci. Am. Suppl., vol. 52, p. 21504, 1901.

743 —— Moraines and maximum diurnal temperature.
Abstracts: Science, new ser., vol. 14, pp. 794–795, 1901.
Sci. Am. Suppl., vol. 52, p. 21504, 1901.
Describes certain glacial phenomena.

744 **Turner** (Henry W.). The geology of the Great Basin in eastern California and southwestern Nevada.
Abstracts: Jour. Geol., vol. 9, p. 73 (½ p.), 1901; Geol. Soc. Am., Bull., vol. 12, p. 498 (¾ p.), 1901.
Describes the structure of the region and its general stratigraphic features.

745 —— Perknite (lime-magnesia rocks).
Jour. Geol., vol. 9, pp. 507–511, 1901.
Describes the character and occurrence of a new rock type and gives chemical analyses of rocks included in this group.

746 —— The mines of Esmeralda County, Nevada.
Mg. and Sci. Press, vol. 82, pp. 73–74, 1901.
Contains notes on the general geology of portions of the County.

747 **Tyrrell** (J. B.). Report on the east shore of Lake Winnipeg and adjacent parts of Manitoba and Keewatin, compiled by D. B. Dowling.
Can. Geol. Surv., new ser., vol. 11, Rept. G., 96 pp., 3 pls., 1901, published in 1900.
Describes the physiography and drainage of the region and the character of the crystalline rocks.

U.

748 **Udden** (J. A.). Geology of Louisa County [Iowa].
Iowa Geol. Surv., vol. 11, pp. 58–126, pl. 4, fig. 1, 2 maps, 1901.
Describes the physiography, the character and distribution of the Carboniferous and Pleistocene deposits and the occurrence of economic products.

749 —— Geologie of Pottawattamie County [Iowa].
Iowa Geol. Surv., vol. 11, pp. 202–277, pl. 6, figs. 13–15 and map, 1901.
Describes the physiography, the character and occurrence of the Carboniferous, Cretaceous, and Pleistocene strata and the occurrence of economic products.

750 **Ulrich** (E. O.). Systematic paleontology, Eocene Arthropoda.
Md. Geol. Surv., Eocene, pp. 116–122, pl. 16, 1901.

751 —— Eocene Molluscoidea (Bryozoa).
Md. Geol. Surv., Eocene, pp. 205–222, pls. 59–60, 1901.

752 **Upham** (Warren). Artesian wells in North and South Dakota.
Minn. Acad. Nat. Sci., Bull., vol. 3, pp. 370–379, 1901.

753 —— Pre-Glacial erosion in the course of the Niagara gorge, and its relation to estimates of post-Glacial time.
Am. Geol., vol. 28, pp. 235–244, 1901.
Gives the author's views of the glacial history of the region and discusses their bearing on estimates of post-Glacial time.

754 —— The antiquity of the races of mankind.
Am. Geol., vol. 28, pp. 250–254, 1901.
Reviews the evidences indicating the pre-Glacial origin of man.

755 —— [Review of "Iowa Geological Survey, volume 11."]
Am. Geol., vol. 28, p. 258, (½ p.), 1901.

756 —— The Toronto and Scarboro drift series [Ontario].
Am. Geol., vol. 28, pp. 306–316, 1901.
Quotes Coleman's description of these beds and discusses the bearing of the evidences on the existence of interglacial epochs of moderate oscillations of the ice border.

757 —— [Review of "Geological Survey of Canada, Annual Report, new series, volume 11, 1898."]
Am. Geol., vol. 28, pp. 321–322, 1901.

V.

758 **Van Hise** (Charles R.). Some principles controlling the deposition of ores.
Am. Inst. Mg. Engrs., Trans., vol. 30, pp. 27–177, figs. 1–10, 1901.
Abstracts: Am. Jour. Sci., 4th ser., vol. 11, p. 90 (½ p.), 1901; Eng. & Mg. Jour., vol. 72, pp. 699–702, 1901.
This subject is discussed under the following general heads: Three zones of the lithosphere; the water content and openings in rocks; physico-chemical principles controlling the work of underground waters; general geologic work of underground waters; the precipitation of ores by ascending waters; precipitation of ores by ascending and descending waters combined; the association of certain ores; concentration; enrichment and diminution of richness in depth; special factors affecting the concentration of ores, and the classification of ore deposits.

759 —— The iron-ore deposits of the Lake Superior region.
U. S. Geol. Surv., 21st Ann. Rept., Pt. III, pp. 305–434, pls. xlviii–lix, 1901.
Describes the general stratigraphy and occurrence of iron ores in the several districts of the Lake Superior region. The Mesabi district is by C. R. Van Hise and C. K. Leith. The Vermillion iron-bearing district is by C. R. Van Hise and J. Morgan Clements.

760 —— The geology of ore deposits.
Science, new ser., vol. 14, pp. 745–757, figs. 1–6, 785–793, 1901.
Abstract: Sci. Am. Suppl., vol. 52, p. 21504, 1901.
Discusses the evidences that metallic ores and gangue are deposited by underground waters.

761 **Van Hise** (Charles R.). [Discussion of "Ice ramparts," by E. R, Buckley].

Wis. Acad. Sci. Arts and Letters, Trans., vol. 13, Pt. I, pp. 158–162, pls. 14–18, 1901.

Compares the phenomena of ice deformation with those of crustal deformation.

762 **Van Ingen** (Gilbert). The Siluric fauna near Batesville, Arkansas, I.

School of Mines Quart., vol. 22, pp. 318–328, fig. 1, 1901.

Describes the geologic relations of the strata. Includes a bibliography.

763 —— The Siluric fauna near Batesville, Arkansas.

School of Mines Quart., vol. 23, pp. 34–74, figs. 9–22, 1901.

Describes the characters of the various species collected.

764 —— [Paleozoic rocks of northwestern New Jersey.]

Abstract: Am. Geol., vol. 27, pp. 42–43, 1901.

Contains considerable data on the Paleozoic strata and faunas of New Jersey.

765 **Vaughan** (T. Wayland). Eocene Coelenterata.

Md. Geol. Surv., Eocene, pp. 222–232, pl. 61, 1901.

766 —— Some fossil corals from the elevated reefs of Curaçao, Arube, and Bonaire.

Sammlungen d. Geol. Reichs-Museum, Leiden, ser. 11, Bd. 11, Heft 1, 1901.

766a —— The stony corals of the Porto Rican waters.

U. S. Fish Comm., Bull., vol. 2, for 1900, pp. 289–320, pls. i–xxxviii, 1901.

In addition to describing recent species of corals, gives notes on fossil species from the United States and the West Indies.

767 —— Shell Bluff, Georgia, one of Lyell's original localities.

Abstract: Science, new ser., vol. 13, p. 270, 1901.

Contains abstract of paper read before the Geological Society of Washington.

768 —— Review of recent papers on Bahaman corals.

Science, new ser., vol. 14, pp. 497–498, 1901.

769 —— The copper mines of Santa Clara province, Cuba.

Eng. & Mg. Jour., vol. 72, pp. 814–816, 4 figs., 1901.

Describes the geology and occurrence and character of the ore bodies.

770 **Vaux** (George) and (William S., jr.). Observations made in 1900 on glaciers in British Columbia.

Phil. Acad. Nat. Sci., Proc. for 1901, pp. 213–215, 1901.

Notes on movements of the glaciers.

W.

771 **Walcott** (Charles D.). Cambrian Brachiopoda; Obolella subgenus Glyptias; Bicia; Obolus, subgenus Westonia; with description of new species.

U. S. Nat. Mus., Proc., vol. 23, pp. 669–695, 1901.

772 —— The work of the United States Geological Survey in relation to the mineral resources of the United States.

Am. Inst. Mg. Engrs., Trans., vol. 30, pp. 3–26, with map, 1901.

Gives a general account of the work of the U. S. Geological Survey in the development of the mineral resources of the country.

773 —— Twenty-second Annual Report of the Director of the United States Geological Survey to the Secretary of the Interior, 1900–1901.

U. S. Geol. Surv., 22d Ann. Rept., Pt. I, pp. 1–207, pls. i–xxiv, 1901.

Gives an account of the work of the U. S. Geological Survey for the year.

774 —— Sur les formations Pré-Cambriennes fossilifères.

Int. Cong. Geol., Compte Rendu, viii session, pp. 299–312, 1901.

Describes the lithologic and faunal characters of the pre-Cambrian strata in various parts of the United States.

775 **Walker** (B. E.). List of the published writings of Elkanah Billings.

Can. Rec. Sci., vol. 8, pp. 366–388, 1901.

776 **Wanner** (Atreus). A new species of Olenellus from the Lower Cambrian of York County, Pennsylvania.

Wash. Acad. Sci., vol. 3, pp. 267–272, pls. 31–32, 1901.

777 **Ward** (Lester F.). Geology of the Little Colorado Valley [Arizona].

Am. Jour. Sci., 4th ser., vol. 12, pp. 401–413, 1901.

Describes the character and occurrence of the several subdivisions of the Mesozoic strata of the region.

778 —— [Review of "Sur quelques Microorganismes des combustibles fossiles," by B. Renault.]

Science, new ser., vol. 13, pp. 577–581, 1901.

779 —— The petrified forests of Arizona.

Smith. Inst., Ann. Rept. 1899, pp. 289–307, 1901.

780 **Warren** (C. H.). [Review of "The structural relations of the amygdaloidal melaphyre in Brookline, Newton, and Brighton, Mass.," by Henry T. Burr.]

Am. Jour. Sci., 4th ser., vol. 12, pp. 80–81, 1901.

781 **Warren** (C. H.). [Reviews of "Elements of mineralogy, crystallography and blowpipe analysis," by A. J. Moses and C. L. Parsons; and "A text-book of important minerals and rocks," by S. E. Tillman.]
Science, new ser., vol. 13, pp. 267–268, 1901.

782 —— **Penfield** (S. L.) and. Some new minerals from the zinc mines at Franklin, N. J., and note concerning the chemical composition of ganomalite.
See Penfield (S. L.) and Warren (C. H.), 603.

783 **Washington** (Henry S.). The foyaite-ijolite series of Magnet Cove [Arkansas]; a chemical study in differentiation. I.
Jour. Geol., vol. 9, pp. 607–622, 1901.
Comprises a study of the chemical composition of several rock types and a discussion of their relations.

784 —— The foyaite-ijolite series of Magnet Cove [Arkansas]; a chemical study in differentiation. II.
Jour. Geol., vol. 9, pp. 645–670, figs. 1–3, 1901.
Describes the petrographic characters of the rocks and compares them with similar rocks from other regions. Discusses differentiation in laccolithic magmas.

785 —— The rocks of Lake Winnepesaukee, New Hampshire
Abstract: Am. Geol., vol. 27, p. 44 (½ p.), 1901.
Contains brief notes on the rocks.

786 —— A chemical study of the glancophane schists.
Am. Jour. Sci., 4th ser., vol. 11, pp. 35–59, 1901.
Abstract: Am. Geol., vol. 27, pp. 184–185, 1901.
Describes the microscopic and chemical characters of these schists from several foreign countries and from western United States.

787 **Watson** (Thomas Leonard). The granitic rocks of Georgia and their relationships.
Am. Geol., vol. 27, pp. 199–225, pls. 17–24, 1901.
Describes the microscopic and chemical and mineralogic characters of the varieties of granite and discusses the evidence of their intrusive origin.

788 —— The Georgia bauxite deposits; their chemical constituents and genesis.
Am. Geol., vol. 28, pp. 25–45, pl. 7, 1901.
Describes the general geology of the bauxite area and the occurrence, geologic position, and chemical composition of the ore and discusses its origin.

789 —— On the origin of the phenocrysts in the porphyritic granites of Georgia.
Jour. Geol., vol. 9, pp. 97–122, figs. 1–6, 1901.
Abstracts: Am. Geol., vol. 28, pp. 58–59, 1901; Am. Nat., vol. 35, pp. 947–948, 1901.
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790 **Watson** (Thomas Leonard). [Review of "The Bauxite deposits of Arkansas," by Charles Willard Hayes.]
Jour. Geol., vol. 9, pp. 737-739, 1901.

791 —— Weathering of granitic rocks of Georgia.
Geol. Soc. Am., Bull., vol. 12, pp. 93-108, pls. 6-11, 1901
Abstracts: Science, new ser., vol. 13, p. 137, 1901; Am. Nat., vol. 35, p. 947 (⅓ p.), 1901.
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792 **Watson** (R. Lind). Auriferous deposits of Wreck Bay, Jordan River, and other localities of Vancouver Island [Canada].
Mines and Minerals, vol. 21, pp. 488-489, 1 fig., 1901.
Describes placers of the region.

793 **Weatherby** (W. J.). The Mogollon range, New Mexico.
Mines and Minerals, vol. 22, pp. 97-101, 4 figs., 1901.
Describes the general geology and mineral resources of the region.

794 **Weed** (Walter Harvey). The enrichment of gold and silver veins.
Am. Inst. Mg. Engrs., Trans., vol. 30, pp. 426-448, figs. 1-9, 1901.
Discusses the genesis of rich ore bodies occurring near ground water level and of those found in deep mine workings and the chemical reactions which have taken place during the process of ore deposition. Describes the author's observations and those of other geologists in various mines.

795 —— Types of copper deposits in the southern United States.
Am. Inst. Mg. Engrs., Trans., vol. 30, pp. 449-504, figs. 1-22, 1901.
Describes the character and occurrence of copper ores in certain districts and discusses relations of the ores of the regions with these type deposits.

796 —— Notes on the Carolina gold deposits.
Eng. and Mg. Jour., vol. 72, p. 494, 1901.
Brief notes on the character of the ores.

797 —— The El Paso tin deposits [Texas].
U. S. Geol. Surv., Bull. No. 178, pp. 1-15, pl. 1, figs. 1-4, 1901.
Describes the general geology of the region and the occurrence and character of the ore-bearing veins.

798 —— and **Pirsson** (L. V.). Geology of the Shonkin sag and Palisade Butte laccoliths in the Highwood Mountains of Montana.
Am. Jour. Sci., 4th ser., vol. 12, pp. 1-17, figs. 1-10, 1901.
Abstract: Geol. Mag., new ser., dec. 4, vol. 8, p. 423, 1901.
Describes the physiography of the region, the occurrence and character of the laccoliths and the chemical characters of the shonkinite and syenite.

799 **Weed** (Walter Harvey) and **Pirrson** (L. V.). Missourite, a new leucite rock from the Highwood Mountains of Montana.

Yale Bicentennial publications. Cont. to Mineral. and Petrog. pp. 457–466, 1901. (From Am. Jour. Sci., 4th ser., vol. 2, pp. 315–323, 1896.)

800 **Weeks** (Fred Boughton). An occurrence of tungsten ore in eastern Nevada.

U. S. Geol. Surv., 21st Ann. Rept., Pt. VI, pp. 319–320, 1901

Abstract: Eng. and Mg. Jour., vol. 72, pp. 8–9, 1901.

801 **Weller** (Stuart). Correlation of the Kinderhook formations of southwestern Missouri.

Jour. Geol., vol. 9, pp. 130–148, 1901.

Reviews recent correlation of these strata and describes the occurrence and faunas of the several formations which make up the Kinderhook group.

802 —— [Review of "The Oriskany fauna of Becraft Mountain, Columbia Co., N. Y.," by J. M. Clarke.]

Jour. Geol., vol. 9, pp. 278–279, 1901.

803 —— [Review of the University Geological Survey of Kansas, vol. 4, Paleontology, Part II, by Samuel W. Williston].

Jour. Geol., vol. 9, pp. 362–363, 1901.

804 —— Kinderhook faunal studies. III. The faunas of beds No. 3 to No. 7 at Burlington, Iowa.

St. Louis Acad. Sci., Trans., vol. 11, pp. 147–214, pls. 12–20, 1901.

Describes species collected from the various beds and discusses the correlations.

805 —— A preliminary report on the Paleozoic formations of the Kittatinny Valley in New Jersey.

N. J. Geol. Surv., Ann. Rept. for 1900, pp. 1–8, 1901.

Describes the character and occurrence of the subdivisions of the Cambrian and Ordovician strata in New Jersey.

806 —— **Kummell** (Henry B.) and. Paleozoic limestones of Kittatinny Valley, New Jersey.

See Kummel (H. B.) and Weller (S.), 457.

807 —— **Smith** (James Perrin) and. Prodromites, a new ammonite genus from the Lower Carboniferous.

See Smith (J. P.) and Weller (Stuart), 711.

808 **Wells** (Horace L.). Sperrylite, a new mineral.

Yale Bicentennial publications. Cont. to Mineral. and Petrog., pp. 151–156, 1901. (From Am. Jour. Sci., vol. 37, pp. 67–70, 1889.)

809 —— On the composition of pollucite and its occurrence at Hebron, Me.

Yale Bicentennial publications. Cont. to Mineral. and Petrog., pp. 183–192, 1901. (From Am. Jour. Sci., vol. 41, pp. 213–220, 1891.)

809a **White** (David). Two new species of Algæ from the Upper Silurian of Indiana.
U. S. Nat. Mus., Proc., vol. 24, pp. 265–270, pls. xvi–xviii, 1901

810 —— Age of the coals at Tipton, Blair County, Pennsylvania.
Geol. Soc. Am., Bull., vol. 12, pp. 473–477, 1901.
Describes the occurrence, character and structure of the strata associated with the coals and discusses their age as indicated by the fossil flora.

811 —— [Review of "Étude sur la flore fossile du basin houiller d'Heraclée (Asie Mineure)" by R. Zeiller.]
Jour. Geol., vol. 9, pp. 192–198, 1901.

812 —— Mr. Lacoe's relation to science.
Wyoming Hist. and Geol. Soc., Proc. and Coll., vol. 6, pp. 55–60, 1901.
Gives an account of his geologic and paleontologic labors.

813 —— The Canadian species of the genus Whittleseya and their systematic relations.
Ottawa Nat., vol. 15, pp. 98–110, pl. 7, 1901.
Describes the occurrence, relation, systematic position and characters of the species.

814 —— Some paleobotanical aspects of the Upper Paleozoic in Nova Scotia.
Can. Rec. Sci., vol. 8, pp. 271–280, 1901.
Discusses the bearing of the paleobotanical data on the age of certain beds in Nova Scotia.

815 **White** (I. C.). Second edition of the geological map of West Virginia.
Am. Geol., vol. 28, pp. 323–329, 1901.
Gives a brief description of the map.

816 —— Geology of West Virginia. [Paper read before the International Mining Congress, Boise, Idaho, June, 1901.]
Mines and Minerals, vol. 22, pp. 153–155, 1901.
Describes briefly the character and succession of the sedimentary strata of the State.

817 **White** (Mark). Geology of the Glass Mountains of western Oklahoma.
Kans. Acad. Sci., Trans., vol. 17, pp. 199–200, 1901.
Gives a section of the Cretaceous strata.

818 **White** (Theodore G.). [Faunas of the Lower Ordovician at Glens Falls, N. Y.]
Abstract: Am. Geol., vol. 27, p. 43 (½ p.), 1901.
Gives results of the author's detailed studies.

819 **Whiteaves** (J. F.). Description of a new species of Unio from the Cretaceous rocks of the Nanaimo coal field. Vancouver Island.
Ottawa Nat., vol. 14, pp. 177–179, 1 fig., 1901.

820 **Whiteaves** (J. F.). Note on a supposed new species of Lytoceras from the Cretaceous rocks at Denman Island in the Strait of Georgia [Canada].
Ottawa Nat., vol. 15, pp. 31–32, 1901.

821 **Whitehead** (Cabell), **Chatard** (T. M.), and. An examination of the ores of the Republic Mine, Washington.
See Chatard (T. M.) and Whitehead (C.), 125.

822 **Whitfield** (R. P.) assisted by **Hovey** (E. O.). Catalogue of the types and figured specimens in the paleontological collection of the geological department, American Museum of Natural History; Lower Carboniferous to Pleistocene inclusive.
Am. Mus. Nat. Hist., Bull., vol. 11, pt. 4, pp. 357–500, 1901.

823 **Whitfield** (R. P.). Note on a very fine example of Helicoceras stevensoni preserving the outer chamber.
Am. Mus. Nat. Hist., Bull., vol. 14, p. 219, pl. 30, 1901.

824 **Wieland** (G. R.). A study of some American fossil Cycads. Part IV. On the microsporangiate fructification of Cycadeoidea.
Am. Jour. Sci., 4th ser., vol. 11, pp. 423–436, figs. 1–3, 1901.
Continues the description of the author's studies of the fructification of Cycadeoidea, which appeared in the American Journal of Science for March, 1899.

825 **Williams** (E. H., jr.). The alleged Parker channel. [Pennsylvania.]
Geol. Soc. Am., Bull., vol. 12, p. 463, 1901.
Describes abandoned channel of Allegheny River.

826 **Williams** (Henry Shaler). The discrimination of time values in geology.
Jour. Geol., vol. 9, pp. 570–585, 1901.
Discusses the criteria upon which the classification of strata should depend and proposes a plan of a biochronic classification and nomenclature.

827 —— Points involved in the Siluro-Devonian boundary question.
Abstract: Geol. Soc. Am., Bull., vol. 12, pp. 472–473, 1901.
Gives brief summary of questions in dispute.

828 —— [Reviews of "The Eocene deposits of Maryland" and "Systematic paleontology;" "Annual Report of the Geological Survey of Arkansas, 1892, Vol. V;" "Summary report on the operations of the Geological Survey of Canada" by G. M. Dawson; and "A revision of the genera and species of Canadian Paleozoic Corals—The Madreporaria aporosa and the Madreporaria rugosa" by L. M. Lambe.]
Am. Jour. Sci., 4th ser., vol. 12, pp. 77–80, 1901.

829 **Williams** (Henry Shaler). [Reviews of "Geological Survey of Canada, new series, vol. 11;" "Geological and Natural History Survey of Minnesota, Final Report, vol. 6;" "Iowa Geological Survey, vol. 11;" and "Dragons of the air, an account of extinct flying reptiles" by H. G. Seeley.]

Am. Jour. Sci., 4th ser., vol. 12, pp. 394–398, 1901.

830 **Willmott** (A. B.). The Michipicoten Huronian area.

Am. Geol., vol. 28, pp. 14–19, pl. 8, 1901.

Describes the occurrence of the igneous and sedimentary rocks of the region and discusses the stratigraphic succession and age of the sediments.

831 **Willis** (Bailey). Paleozoic Appalachia or the history of Maryland during Paleozoic time.

Md. Geol. Surv., Special Publication, vol. 4, pt. 1, pp. 1–93, pls. i–xii, fig. 1, 1900.

Describes the processes of erosion, sedimentation and deformation, and discusses the Paleozoic history of Maryland and adjacent States.

832 —— Individuals of stratigraphic classification.

Jour. Geol., vol. 9, pp. 557–569, 1901.

Discusses the discrimination of formations by lithologic criteria and the determination of faunal and time divisions.

833 —— Thomas Benton Brooks.

Science, new ser., vol. 13, pp. 460–462, 1901.

Gives an account of his life and geologic researches.

834 —— Oil of the northern Rocky Mountains.

Eng. and Mg. Jour., vol. 72, pp. 782–784, 3 figs., 1901.

Describes the stratigraphy and structure of the region and the probable occurrence of oil.

835 —— **Smith** (George Otis) and. The Clealum iron-ores, Washington.

See Smith (G. O.) and Willis (B.), 709.

836 **Williston** (S. W.). The dinosaurian genus Creosaurus, Marsh.

Am. Jour. Sci., 4th ser., vol. 11, pp. 111–114, fig. 1, 1901.

Reviews previous descriptions and describes new material.

837 —— A new turtle from the Kansas Cretaceous.

Kans. Acad. Sci., Trans., vol. 17, pp. 195–199, pls. 18–22, 1901.

Describes Porthochelys laticeps, n. gen. et sp.

838 **Wilson** (Alfred W. G.). The Medford dike area [Massachusetts].

Boston Soc. Nat. Hist., Proc., vol. 30, pp. 353–374, pls. 1–4, 1901.

Describes the petrographic characters of the crystalline rocks and the glacial phenomena of the region. Includes a bibliography and geologic map.

839 —— Physical geology of central Ontario.

Can. Inst., Trans., vol. 7, pp. 139–186, 8 pls., 10 figs., 4 maps, 1901.

Describes the character of the pre-sedimentary floor of the region, the characters of the Paleozoic series, its post-Paleozoic history, and the glacial phenomena.

840 **Wilson** (Herbert M.). Porto Rico; its topography and aspects.
Am. Geog. Soc., Bull., vol. 32, pp. 220–238, with map, 1900.
Describes physiography of the island.

841 **Winchell** (Alexander N.). Étude minéralogique et pétrographique des roches gabbroïques de l'État de Minnesota, États-Unis, et plus spécialement des anorthosites.
Paris. 164 pp., 1900. (Not seen.)
Abstract: Am. Jour. Sci., 4th ser., vol. 11, p. 89 (⅓ p.), 1901.

842 —— Note on certain copper minerals.
Am. Geol., vol. 28, pp. 244–246, 1901.
Describes occurrence of chalcopyrite and bornite at Butte, Mont.

843 **Winchell** (Newton H.). Glacial lakes of Minnesota.
Geol. Soc. Am., Bull., vol. 12, pp. 109–128, pl. 12, 1901.
Describes the retreat of the ice sheets and the occurrence of the several glacial lakes of the region.

844 —— [Reviews of "A Text-book of important minerals and rocks, with tables for the determination of minerals," by S. E. Tillman, and "The progress of Mineralogy in 1899, an analytical Catalogue of the contributions to that series during the year," by S. H. Hamilton and J. R. Withron, and "New species of Cambrian fossils from Cape Breton," by G. F. Matthew].
Am. Geol., vol. 27, pp. 48–49, 1901.

845 —— [Review of "La Face de la Terre" (Das Antlitz der Erde), by Ed. Suess, and Bulletin of the Hadley laboratory of the University of New Mexico, vol. 2, pt. 1].
Am. Geol., vol. 27, pp. 56–59, 1901.

846 —— [Review of Bulletin No. 4 of the South Dakota School of Mines].
Am. Geol., vol. 27, p. 124 (⅓ p.), 1901.

847 —— [Reviews of "Profiles of Rivers in the United States," by Henry Gannett, and "Guide to the Geology and Paleontology of Niagara Falls and vicinity," by A. W. Grabau].
Am. Geol., vol. 28, pp. 56–57, 1901.

848 —— [Reviews of "Die Ursachen der Oberflächengestaltung des norddeutschen Flachlandes," by Dr. F. Wahnschaffe; "Geologischer Führer durch Campanien," by Dr. W. Deecke; "The Coal and Metal miner's pocketbook of principles, rules, formulas, and tables;" and "Report on the geology of the Philippine Islands," by George F. Becker.]
Am. Geol., vol. 28, pp. 123–127, 1901.

849 **Winchell** (Newton H.). The Archean of the Alps.

Am. Geol., vol. 28, pp. 189-200, 1901.

Reviews paper by Duparc and Mrazec.

850 —— Edward Waller Claypole.

Am. Geol., vol. 28, pp. 247-248, 1901.

Gives a sketch of the life of Prof. Claypole.

851 —— The origin of Australian iron ores.

Am. Geol., vol., 18, pp. 248-250, 1901.

Reviews paper by J. B. Jaquet on "The iron-ore deposits of New South Wales," and compares them with certain deposits in the State of Washington.

852 —— [Reviews of "Geology and water resources of Nez Perce County, Idaho" by I. C. Russel; "Contributions to mineralogy and petrography," edited by S. L. Penfield and L. V. Pirsson; "Preliminary report on the copper-bearing rocks of Douglas County, Wisconsin, containing a preliminary report on the copper-bearing rocks of parts of Washburn and Bayfield Counties," 2d edition, by U. S. Grant; and "An investigation of the buried valley of Wyoming" by William Griffith.]

Am. Geol., vol. 28, pp. 319-324, 1901.

853 —— Fundamental changes in the Archean and Algonkian, as understood by Prof. Van Hise, of the United States Geological Survey.

Am. Geol., vol. 28, pp. 385-388, 1901.

Reviews a recent paper by Prof. Van Hise.

854 **Withrow** (James R.), **Hamilton** (S. Harbert) and. The progress of mineralogy in 1899, an analytical catalogue of the contributions to science during the year.

See Hamilton (S. H.) and Withrow (J. R.), 337.

855 **Wood** (Elvira). Marcellus (Stafford) limestones of Lancaster, Erie County, N. Y.

N. Y. State Mus., Bull. No. 49, pp. 139-181, fig. 1, pl. 9, 1901.

Describes their stratigraphic relations and lithologic and faunal characters.

856 —— A new crinoid from the Hamilton of Charlestown, Indiana.

Am. Jour. Sci., 4th ser., vol. 12, pp. 297-300, pl. v, fig. 1, 1901.

Describes Gemnnæocrinus carinatus n. sp.

857 **Woodworth** (Jay Backus). Original micaceous cross-banding of strata by current action.

Am. Geol., vol. 27, pp. 281-283, figs. 1-2, 1901.

Describes the phenomena occurring in glacial sand of Massachusetts and refers to descriptions of somewhat similar occurrences.

858 **Woodworth** (J. Backus). Pleistocene geology of portions of Nassau of Queens County and Borough [New York].

N. Y. State Mus., Bull. No. 48, pp. 618-670, pls. 1-9, figs. 1-9, 1901.

Describes the physiography and character and occurrence of the Pleistocene strata of the region. Includes a summary of glacial history and bibliography.

859 **Woolman** (Lewis). Artesian wells. [New Jersey.]

N. J. Geol. Surv., Ann. Rept. for 1900, pp. 103-171, 1901.

Gives sections of many artesian wells.

860 **Wortman** (J. L.). A new American species of Amphicyon.

Am. Jour. Sci., 4th ser., vol. 11, pp. 200-204, figs. A and B, 1901.

Describes the characters of the skull and the relations of the Amphicyon group.

861 —— Studies of Eocene Mammalia in the Marsh Collection, Peabody Museum.

Am. Jour. Sci., 4th ser., vol. 11, pp. 333-348, pl. v, figs. 1-6, pp. 437-450, pl. vi, figs. 7-17, 1901.

Discusses the relations of the Carnivora and Creodonta, and describes the characters of some forms of Canidæ, including a few new species.

862 —— Studies of Eocene Mammalia in the Marsh Collection, Peabody Museum.

Am. Jour. Sci., 4th ser., vol. 12, pp. 143-154, figs. 18-30, 1901.

Describes Viverravus Marsh, V. gracilis Marsh, minutus n. sp., and Oödectes herpestoides n. gen. et sp.

863 —— Studies of Eocene Mammalia in the Marsh Collection, Peabody Museum.

Am. Jour. Sci., 4th ser., vol. 12, pp. 193-206, figs. 31-43, 1901.

Continues description of Oödectes herpestoides n. sp., and describes Triacodon fallax Marsh, Ziphacodon rugatus Marsh, Harpalodon sylvestris Marsh, Aelurotherium latidens Marsh, and Ae. bicuspis n. sp.

864 —— Studies of Eocene Mammalia in the Marsh Collection, Peabody Museum.

Am. Jour. Sci., 4th ser., vol. 12, pp. 281-296, pls. 1-4, fig. 44, 1901.

Gives the important characters by which the Creodonta are distinguished from the Carnassidentia, and describes Harpagolestes macrocephalus n. gen. et sp., and Dromocyon vorax Marsh.

865 —— Studies of Eocene Mammalia in the Marsh Collection, Peabody Museum.

Am. Jour. Sci., 4th ser., vol. 12, pp. 377-382, figs. 45-48 and 421-432, pls. 8-9, figs. 49-60, 1901.

Continuous description of Dromycyon vorax Marsh.

866 **Wright** (G. F.). Geology and the deluge.

McClure's Mag., vol. 17, pp. 124-139, June, 1901. (Not seen.)

ADDENDA TO BIBLIOGRAPHIES FOR PREVIOUS YEARS.

1893	1894	1896	1897	1899	
106	108	110	111	112	499
107	109			113	529
				114	530
				176	636

1901				
1	117	380	573	747
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46	256	460	657	841
115	257	516	683	
116	350	546	727	

CLASSIFIED KEY TO THE INDEX.

INDEX.

[The numbers refer to entries in the Bibliography.]

[a] Includes geologic maps of the whole or any part of the States mentioned.

O

PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Bulletin No. 203.]

The serial publications of the United States Geological Survey consist of (1) Annual Reports, (2) Monographs, (3) Professional Papers, (4) Bulletins, (5) Mineral Resources, (6) Water-Supply and Irrigation Papers, (7) Topographic Atlas of United States—folios and separate sheets thereof, (8) Geologic Atlas of United States—folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists may be had on application.

The Bulletins (which were formerly sold, but a joint resolution approved May 16, 1902, directed that they should be distributed gratuitously) treat of a variety of subjects, and the total number issued is large. They have therefore been classified into the following series: A, Economic geology; B, Descriptive geology; C, Systematic geology and paleontology; D, Petrography and mineralogy; E, Chemistry and physics; F, Geography; G, Miscellaneous. This bulletin is the twenty-third in Series G, the complete list of which follows:

BULLETINS, SERIES G, MISCELLANEOUS.

2. Gold and silver conversion tables, giving the coining values of troy ounces of fine metal, etc., computed by Albert Williams, jr. 1883. 8 pp.

7. Mapoteca geologica Americana: A catalogue of geological maps of America (North and South), 1752-1881, in geographic and chronologic order, by Jules Marcou and John Belknap Marcou. 1884. 184 pp.

25. The present technical condition of the steel industry of the United States, by Phineas Barnes. 1885. 85 pp.

26. Copper smelting, by Henry M. Howe. 1885. 107 pp.

44. Bibliography of North American geology for 1886, by Nelson H. Darton. 1887. 35 pp.

75. Record of North American geology for 1887-1889, inclusive, by Nelson Horatio Darton. 1891. 173 pp.

91. Record of North American geology for 1890, by Nelson Horatio Darton. 1891. 88 pp.

99. Record of North American geology for 1891, by Nelson Horatio Darton. 1892. 73 pp.

100. Bibliography and index of the publications of the U. S. Geological Survey, 1879-1892, by Philip Creveling Warman. 1893. 495 pp.

127. Catalogue and index of contributions to North American geology, 1732-1891, by Nelson Horatio Dartin. 1896. 1,045 pp.

130. Bibliography and index of North American geology, paleontology, petrology, and mineralogy for 1892 and 1893, by Fred Boughton Weeks. 1896. 210 pp.

131. Report of progress of the division of hydrography for the calendar years 1893 and 1894, by Frederick Haynes Newell. 1895. 126 pp.

135. Bibliography and index of North American geology, paleontology, petrology, and mineralogy for the year 1894, by F. B. Weeks. 1896. 141 pp.

140. Report of progress of the division of hydrography for the calendar year 1895, by Frederick Haynes Newell. 1896. 356 pp.

146. Bibliography and index of North American geology, paleontology, petrology, and mineralogy for the year 1895, by F. B. Weeks. 1896. 130 pp.

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From Senator Alger

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DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

FOSSIL FLORA

OF THE

JOHN DAY BASIN

OREGON

BY

FRANK HALL KNOWLTON

WASHINGTON
GOVERNMENT PRINTING OFFICE
1902

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DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., July 15, 1902.

SIR: I have the honor to transmit herewith the manuscript and illustrations of a paper entitled Fossil Flora of the John Day Basin, Oregon, and to request its publication as a bulletin of the Survey.

Very respectfully,

F. H. KNOWLTON,
Paleontologist.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

FOSSIL FLORA OF THE JOHN DAY BASIN, OREGON.

By F. H. Knowlton.

INTRODUCTION.

For a number of years I have been gradually accumulating material for a thorough revision of the Tertiary floras of the Pacific slope. Fossil plants are known to occur at numerous points within this area, and their study and identification has already furnished valuable data bearing on the geological history of the region, and when still further exploited it is confidently expected that they will afford more exact data for the use of geologists. This investigation is progressing satisfactorily, and at no distant day it is hoped to have it in form for final publication.

From time to time various members of the United States Geological Survey, as well as others not connected with this organization, have sent in small collections of fossil plants for determination. These have been studied and reported upon as fully as the condition of the problem permitted, so that the determinations could be immediately available to geologists, but with the reservation that none of the questions could be fully settled until all known material had been studied and properly correlated.

The rich fossil plant deposits in the John Day Basin, as set forth more fully in the historical account which follows, have been known for a period of nearly fifty years, but their study has been carried on in a more or less desultory manner. There has also been considerable confusion as to the horizons whence these plants came. As various species of plants described originally from the John Day region were detected in various other localities in Oregon, and in surrounding areas, as central Washington, western Idaho, and northern California, it became more than ever apparent that a thorough study of all material obtainable from this type area would be necessary before any definite or satisfactory conclusions could be reached.

The immediate incentive for this revision was furnished by the receipt of a considerable collection of plants, made by Dr. John C. Merriam in 1900 while he was in charge of an expedition into this region made under the auspices of the University of California.

When these plants were submitted to me for study, it was thought possible to present their description, together with a revision of our knowledge of the previously known forms, within a space sufficiently small to permit the publication of the matter as an appendix to a paper on the general geology of the area, then in preparation by Dr. Merriam. But it soon became apparent that this could not be adequately done within the space available, and a short preliminary report was prepared for and published by Dr. Merriam.[a] The results of a complete restudy of all available fossil plant material from the John Day Basin are now presented.

I wish to record my great indebtedness to Dr. Merriam, who not only accompanied me at a considerable personal sacrifice on a trip through the region in 1901, but placed unreservedly at my disposal all material bearing in any way on the problem then in the paleontological museum of the University of California. To Dr. Arthur Hollick I am indebted for the loan of all material from the John Day region belonging to Columbia University, and now deposited in the New York Botanical Garden at Bronx Park. This material, together with the rich collections belonging to the United States National Museum, represents practically all now known to have come from the John Day Basin.

GEOGRAPHIC LOCATION AND TOPOGRAPHIC FEATURES.

The John Day Basin is situated in the north-central portion of the State of Oregon. It lies mainly in Grant County, but extends also into the northeastern portion of Crook County and the southern portions of Gilliam, Morrow, and Umatilla counties. It is rudely rectangular in outline, and is almost completely surrounded by the Blue Mountains, whose rugged eastern ridges rise to a height of over 6,000 feet, those to the west being lower and made up largely of Tertiary lavas, which form regular and often flat-topped ridges.

John Day River, with its numerous branches and tributaries, draining an area of approximately 10,000 square miles, has a general westward course through the basin, which it leaves on its west side through a gap between the north and south ranges of the Blue Mountains; thence its course is north to the Columbia.

When viewed from an eminence the basin presents a rough and rugged appearance and bears abundant evidence of former volcanic activity in the shape of ridges and plateaus, often several thousand feet in height, made up of volcanic flows of various kinds, as well as vast deposits of ashes, tuffs, and occasionally sands and gravels. Around these ridges and plateaus the water courses have cut deep and often narrow canyons, especially in the soft ashes and tuffs, but occasionally also through the massive basalts, rhyolites, and andesites.

[a] A contribution to the geology of the John Day Basin: Univ. Cal., Bull. Dept. Geol., Vol. II, No. 9, April, 1901, pp. 269-314.

The area of land under cultivation is extremely limited, being confined to the scattered narrow bottoms along the main streams. With the exception of a growth of pines along the higher ridges, the tree growth is confined to a fringe of cottonwoods and willows along the water courses and a few scattered junipers on the lower ridges. The remainder of the country, when not too rugged, is or was formerly covered with a luxuriant growth of grasses, but overstocking has already seriously impaired the value of the ranges for grazing purposes.

HISTORY OF EXPLORATION IN THE JOHN DAY BASIN.

For more than a quarter of a century the John Day Basin has been widely known for its abundant deposits of plant and animal fossils. The first of its fossil riches to be discovered were mammalian remains in the form of teeth and fragments of bones from the Crooked River region, brought back by a company of soldiers who traversed the region in 1861. Some of these fossils fell into the hands of Rev. Thomas Condon, then located in The Dalles. Condon recognized the value of the discovery, and early in the following year he obtained permission to accompany a party of soldiers taking supplies to the military post at Harney Valley. On the way out they passed through the Crooked River region, where Condon obtained fossils, and on the return trip by way of Camp Watson, a post long ago abandoned, he discovered rich plant deposits on Bridge Creek. In 1863 and 1864 Condon spent some weeks in each season in exploring along Bridge Creek and John Day River, in the latter region discovering and naming Turtle Cove, a locality which has afforded a large proportion of the vertebrate remains thus far brought to light in this region.

In the fall of 1871 Prof. O. C. Marsh, of Yale University, in company with a large party of students and others, under the guidance of Condon, made an extended trip through the basin, collecting vertebrate remains, principally from what are now known as the "John Day" and "Mascall" beds. From this date until 1877 parties in the employ of Marsh continued collecting throughout the region, but they appear to have procured only animal remains. As these vertebrate remains were found in such abundance and so well preserved, the region continued to attract students. Thus in 1878 and 1879 collections were made for Prof. E. D. Cope; in 1882 for the United States Geological Survey, under the direction of Professor Marsh, and in 1889 by Prof. W. B. Scott, for Princeton University. In 1899 and 1900 Dr. John C. Merriam, with a large party, collected extensively throughout the region in the interests of the University of California. His attention was mainly devoted to securing vertebrate remains, but he also obtained a small and extremely interesting collection of plants from Cherry

Creek, Clarnos Ferry, Bridge Creek, Van Horn's ranch, and other places. These plants will be noticed later.

As already stated, Professor Condon was the first to discover the rich plant beds on Bridge Creek. His collections from this locality, from Currant Creek, and possibly other places within the basin, were probably made during several years, and were ultimately placed in the hands of the late Dr. J. S. Newberry, of Columbia University, for study. As the partial results of his study Dr. Newberry published, in March, 1883, brief characterizations of fifteen new species of plants.[a] These species, as well as several others, were more fully described and figured in his Later Extinct Floras of North America,[b] a posthumous work issued under the editorship of Dr. Arthur Hollick in 1898. The publication of the latter work, containing as it did the illustrations, made it possible for the first time to be certain of Newberry's species. All, or nearly all, of the material on which Newberry's work was based ultimately became the property of the United States National Museum, where it now is.

Probably about 1870 Mr. C. D. Voy, a well-known collector of San Francisco, California, made a collecting trip through the basin. He obtained plants from Currant Creek, Bridge Creek, and from a new locality known later as Van Horn's ranch or Belshaw's ranch. These specimens, through the munificence of Mr. D. O. Mills, were presented to the University of California, where they now are. This material was all submitted to Prof. Leo Lesquereux for determination. The exact date on which it came into his hands is uncertain, but it must have been in or before 1878, for a part of the species—certain of those from Van Horn's ranch—were, owing to insufficient labeling, included in his Fossil Plants of the Auriferous Gravel Deposits of the Sierra Nevada,[c] published in that year. The remainder, now known to have come from Currant Creek, Bridge Creek, and Van Horn's ranch, though mainly labeled simply "John Day Valley, Oregon," was described by Lesquereux in his Cretaceous and Tertiary Floras.[d] This work bears the date of 1883, and as it contains descriptions and figures of many of the same species that had been submitted to Dr. Newberry, though of course under different names, it becomes a matter of much importance to fix more exactly the actual time of issue. In the case of Newberry's paper the actual date is easily fixed by the date on the final signature as March 21, 1883. From a note in the first page of the Cretaceous and Tertiary Floras it appears that the manuscript was submitted by Professor Lesquereux on September 27, 1882, and was received by the Director of the United States Geological Survey on October 12, 1882.

[a] Proc. U. S. Nat. Mus., Vol. V, 1883, pp. 502–513.
[b] Mon. U. S. Geol. Survey Vol. XXXV.
[c] Mem. Mus. Comp. Zool., Vol. VI, No. 2.
[d] U. S. Geol. and Geog. Surv. Terr., Mon. VIII, 1883, pp. 239–255.

But the letter of transmittal to the then Secretary of the Interior bears date of November 1, 1883, and as this must have preceded by some months the actual issue of the volume, it is clear that Newberry's paper has precedence, and all names of species established by him, when in conflict with those given by Lesquereux, must stand.

By far the largest collection of fossil plants from this region was made in the summer of 1880 by Maj. (then Capt.) Charles E. Bendire, of the United States Army, who made a short tour through the basin with a large party of the Seventh United States Cavalry. He collected at Bridge Creek, Cherry Creek, and Van Horn's ranch, securing mainly plants, but also a few fish and mammal remains, and this entire collection was presented by him to the United States National Museum. The fish remains were described by Cope,[a] and the plants were submitted to Lesquereux, whose report on those from Van Horn's ranch and Cherry Creek was published in 1888.[b] Lesquereux's report on the Bridge Creek material was prepared and submitted at the same time, but on account of the difficulty in securing figures of the supposed new species, was not published. This manuscript has been in my hands for some years awaiting revision, and, so far as possible, has been incorporated in the present work.

As a preliminary to the preparation of this work, I went over very carefully every specimen in the collection of the United States National Museum from Van Horn's ranch and Cherry Creek, as published upon by Lesquereux. In the case of the specimens from Van Horn's ranch the matrix is so distinctive that no difficulty was experienced in making certain that they actually came from this locality, but when the collection from Cherry Creek was taken up, it at once became evident that some mixing of specimens must have occurred. Lesquereux enumerated thirty species in his paper above quoted, but they are preserved on very different kinds of matrix and represent certain well-known species that have never before been reported from the John Day region. Specimens of some of the matrix of the suspected species were sent to Dr. Merriam, of the University of California, for the purpose of ascertaining whether he had noted matrix of this character at Cherry Creek. It proved to be wholly unlike anything observed by him at this locality, thus in a measure confirming my suspicion of a possible mixture. I am uncertain where the doubtful specimens came from, but from the character of the matrix as well as from the species represented, it seems more than possible that they may have come from the Green River beds of Wyoming. As doubt was thus cast on all of the Cherry Creek material in the United States National Museum collection, I visited the locality myself in the summer of 1901, in company with Dr. Merriam, and made as full a collection as possible. This absolutely

[a] Am. Nat. Vol. XXIII, 1889, p. 625. [b] Proc. U. S. Nat. Mus., Vol. XI, pp. 13-24, Pls. V-XIV.

confirmed the theory that Lesquereux had inadvertently confused at least two localities under the name of Cherry Creek. The typical matrix at Cherry Creek is a hard, yellowish-brown sandstone, which fractures very irregularly, making it difficult to obtain perfect impressions. Only the species known to have come from there, or preserved on matrix so similar as to leave no reasonable doubt that it is the same, are included in the following enumeration.

As already stated, Dr. Merriam obtained small collections of fossil plants during the field seasons of 1899 and 1900. These were submitted to me for determination, and a more or less tentative report was incorporated by Dr. Merriam in his report above mentioned on the geology of the John Day Basin.

During the field season of 1901 I visited the John Day Basin under the guidance of Dr. Merriam and made collections of plants at Cherry Creek, Bridge Creek, and Van Horn's or Belshaw's ranch and vicinity. At the close of the field season some weeks were spent in thoroughly going over the type collections of plants in the paleontological museum of the University of California. It was at this time that the fact was developed that a part of the Van Horn's ranch material had been included by Lesquereux in his Flora of the Auriferous Gravels of California. Inasmuch as these species were mainly the ones upon which rested the correlation between the beds in the John Day Basin and the Auriferous gravels, the detection of the error was of the utmost importance.

GEOLOGICAL FEATURES OF THE JOHN DAY BASIN.

HISTORY OF GEOLOGICAL INVESTIGATION IN THE REGION.

Considerable confusion and uncertainty have existed regarding geological events and their sequence within this area, due in large measure to the fact that observations were either hastily made during brief reconnaissance trips through the region, or were confined to the vicinity of the richer fossil deposits. Even at the present time no detailed geological study of this region has been undertaken. By far the most important contribution to the subject that has thus far been made is that by Dr. John C. Merriam, in the paper already referred to.[a] Before passing to an exposition of his own views Dr. Merriam presents the following brief summary of previous work:

> The first mention of the fossiliferous deposits in the John Day Basin which appears in the literature was made by Dr. Joseph Leidy. In October, 1870, Dr. Leidy presented before the Philadelphia Academy of Sciences[b] a short paper, in which he described "A collection of fossils recently received for examination through the Smithsonian Institution, from Rev. Thomas Condon, of Dalles City, Oregon." The

[a] A contribution to the geology of the John Day Basin: Univ. Cal., Bull. Dept. Geol., Vol. II, No. 9, April, 1901, pp. 269-314.
[b] Proc. Phila. Acad. Nat. Sci., Vol. XXII, 1870, pp. 111-112.

collection consisted of "remains of mammalia obtained by Mr. Condon from the valley of Bridge Creek" (and "Big Bottom of John Day"), "a tributary of John Day's River, Oregon." The collection included new forms of *Paracotylops* (*Merycochœrus*), *Rhinoceros*, and *Anchitherium*. New occurrences of *Agriochœrus*, *Leptomeryx*, *Lophiodon* (?), *Elotherum*, and a Dicotyles-like form were also noted. Most of the previously known species, as identified by Leidy, were forms belonging to the White River fauna, and he probably considered the John Day beds as of nearly the same age as the White River.

In 1873 Professor Marsh described[a] several new fossil mammals obtained by his exploring party in the John Day country in 1871. He referred two forms to the Miocene and one to the Pliocene, thus making the first statement regarding the age of the beds.

In his paper on the great lava flood of the West, Prof. Joseph Le Conte[b] makes the first mention of the structural relations of the John Day formations. His statement regarding the relation of the lava to the John Day beds is in part as follows: "The lava of this region is * * * underlaid by the remarkable fossiliferous Miocene lake deposit of the John Day Valley; erosion has cut through the lava cap into the soft strata beneath."

The earliest general discussion of John Day geology which appears in literature is the following statement published by Marsh[c] in 1875:

"The Blue Mountains formed the eastern and southern shores of this lake, but its other limits are difficult to ascertain, as this whole country has since been deeply buried by successive overflows of volcanic rock. It is only when the latter have been washed away that the lake deposits can be examined. The discovery and first explorations in this basin were made by Rev. Thomas Condon, the present State geologist of Oregon. The typical localities of this Miocene basin are along the John Day River, and this name may very properly be used to designate the lake basin. The strata in this basin are more or less inclined and of great thickness. One section near the John Day River, examined by the writer in 1871 and again in 1873, seems to indicate a thickness of not less than 5,000 feet. The upper beds alone of this series correspond to the deposits in the White River Basin. The lower portion also is clearly Miocene, as shown by its vertebrate fauna, which differs in many respects from that above. Beneath these strata are seen, at a few localities, the Eocene beds containing fossil plants mentioned above. They are more highly inclined than the Miocene beds, and some of them show that they have been subjected to heat. The inferior strata elsewhere are Mesozoic and apparently Cretaceous. Above the Miocene strata Pliocene beds are seen in a few places, but basalt covers nearly all."

In this account we find the name "John Day" first used for the principal fossil beds of the basin. The relation of this horizon to the great lava beds is also correctly stated, though it is not quite clear whether he considered the Pliocene as also covered by the basalt flows. The Pliocene referred to is pretty certainly the Mascall beds. It is known that Marsh camped near the typical exposure of this formation and did some collecting in it. To what Marsh referred in his statements concerning Eocene and Cretaceous it is not certain. He has, however, correctly described the stratigraphic sequence.

In 1880 Prof. E. D. Cope[d] published the following statement concerning the geology of the John Day country:

"The regions of the John Day River and Blue Mountains furnish sections of the formations of central Oregon. Above the Loup Fork or Upper Miocene there is a lava outflow which has furnished the materials of a later lacustrine formation, which contains many vegetable remains. The material is coarse and somewhat gravelly and is found on the Columbia River, and I think also in the interior basin. Professor Condon, in his unpublished notes, calls this the Dalles group.

[a] Am. Jour. Sci., 3d ser., Vol. V, 1873, p. 409.
[b] Am. Jour. Sci., 3d ser., Vol. VII, 1874, p. 167.
[c] Am. Jour. Sci., 3d ser., Vol. IX, 1875, p. 52.
[d] Proc. Am. Philos. Soc., Vol. XIX, 1880, p. 61.

It is in turn overlaid by the beds of the second great volcanic outflow. Below the Loup Fork follows the Truckee group, so rich in extinct mammalia, and below this a formation of shales. These are composed of fine material, and vary in color from a white to a pale brown and reddish-brown. They contain vegetable remains in excellent preservation, and indeterminable fishes. The *Taxodium* nearly resembles that from the shales at Osino, Nevada, and on various grounds I suspect that these beds form a part of the Amyzon group (American Naturalist, June, 1880), with the shales of Osino and of the South Park of Colorado. Below these is a system of fine-grained, sometimes shaly, rocks of delicate gray, buff, and greenish colors containing calamites,[a] which Professor Condon calls the *Calamite* beds. Their age is undetermined."

In spite of Cope's assumption that the plant and fish bearing beds mentioned by him were to be correlated with his Amyzon group,[b] Lesquereux[c] referred the collections from Van Horn's ranch to the late Miocene. In a later statement regarding the John Day stratigraphy,[d] Cope speaks of the calamite beds as doubtless belonging to to the Triassic or Jurassic. This horizon was determined by Lesquereux as Eocene.

Following is the geological section of the John Day region as worked out by Dr. Merriam:[e]

River terraces, with undisturbed Quaternary fossils.

Rattlesnake formation. Gravels, ash, tuff, and rhyolitic lava.

Mascall formation. Ashes, tuffs, and possibly gravels.

Columbia [River] lava. Basaltic flows.

John Day series. Ashes, tuffs, and rhyolitic flows. Sands and gravels near the top. Lower, middle, and upper divisions.

Clarno formation. Ashes, tuffs, and andesitic and rhyolitic lavas.

Chico formation. Sandstones and conglomerates.

Knoxville formation. Black shales.

Pre-Cretaceous sedimentaries, serpentines. Granitic masses of unknown age.

PRE-CRETACEOUS ROCKS.

Although the oldest fossiliferous strata which have thus far been found in the John Day Basin north of the southern portion of the Blue Mountains belong to the Cretaceous, there are formations exposed at a number of points that present the appearance, according to Merriam, of being much older. Thus, on the Middle Fork of the John Day, about 5 miles above Ritter, there are certain sedimentary rocks bordering an area of quartz-diorite which are much more indurated and deformed than any known Cretaceous within the basin.

At Spanish Gulch, 12 miles southwest of Dayville, the Chico Cretaceous is seen resting upon serpentine, which has the appearance of being intruded into it. At the head of the gulch the serpentine is separated from what was taken to be the Chico conglomerate by a zone of schist and quartzite. Not far from this locality there is associated with the serpentine a considerable thickness of quartzite with quartz veins, which have produced some gold. Limestones quite different from any seen in the Chico are also exposed here. From the same neighborhood the writer obtained a specimen of a granitic rock, said to form one wall of a tunnel.

Although no direct proof can be presented, it seems probable that some of the rocks associated with the serpentine at Spanish Gulch are older than the Cretaceous.[f]

[a] This is apparently *Equisetum oregonense* Newberry, q. v.
[b] Cope, Am. Nat. 1879, p. 332, Late Eocene or Early Miocene, Nevada.
[c] Proc. U. S. Nat. Mus., Vol. XI, 1888, p. 13.
[d] Mon. U. S. Geol. and Geogr. Surv. Terr., Vol. III, 1884, p. 16.
[e] Merriam, op. cit., p. 278
[f] Ibid, p. 280.

At a point 6 miles south of Clarnos Ferry, near the junction of Muddy and Currant creeks, there are several hundred feet of black slates. No fossils have been found in these slates, which seem older than the Knoxville shales.

KNOXVILLE AND CHICO BEDS.

No fossiliferous Knoxville beds have been found within the basin, and the presence of this formation is based on purely lithological grounds. At Mitchell there is exposed a section, thought by Merriam to be hardly less than 3,000 or 4,000 feet in thickness, which is made up of sandstone, conglomerate, and shale. The lower portion of this section is composed mainly of shale which, from its resemblance to the Knoxville so usually developed in California and south-central Oregon, is assumed to be of this age.

The Chico is exposed at Mitchell and Spanish Gulch. Only a single fossil has thus far been afforded by the Mitchell locality. Fossil invertebrates have, however, been obtained at two localities near Spanish Gulch. These were submitted to Dr. T. W. Stanton, who reports that they indicate a "horizon at or very near the base of the Chico formation."

CLARNO FORMATION.

The name Clarno formation has been given by Merriam to a series of beds some 400 feet in thickness which rests on the Chico or Knoxville, and which consists almost entirely of eruptive materials in the form of rhyolite and andesite flows and ash and tuff beds. It is found in typical exposures at Clarnos Ferry, near the town of Fossil, on Cherry Creek, and near Burnt ranch.

> Where the Clarno has been found in contact with the John Day there is no apparent angular unconformity of the strata. The difference in induration and weathering is, however, very noticeable. The sedimentary parts of the Clarno show a much greater degree of induration than the John Day beds immediately above, and tend at all localities to form steep bluffs, ornamented frequently with balanced rocks or grotesque figures.[a]

Thus far neither vertebrate nor invertebrate remains have been found in the Clarno, but at most of the localities where carefully exploited fossil plants have been found, often in abundance. The celebrated Bridge Creek locality falls within this formation, occurring at the base of the superimposed John Day beds. I visited this locality in 1901 and obtained a small collection. The plants occur abundantly in a reddish shale, which weathers whitish. The other plant localities in the Clarno will be listed later.

[a] Merriam, op. cit., p. 286.

JOHN DAY SERIES.

Resting directly upon and apparently conformable with the Clarno formation is a thick series of regularly stratified sediments now widely known as the John Day beds. This series of beds is found quite generally throughout the basin, and represents what was called by Marsh the deposits of the John Day Lake. The beds are made up almost entirely of ashy or tufaceous materials, with occasionally, toward the top, some 100 or 200 feet of a harder, blocky tuff.

> The erosion forms and coloration of the John Day strata are quite characteristic when compared with those of other formations in the basin. In general the beds are colored various shades of red, green, blue, or yellow. In some cases they are white or gray. As will be shown later, the coloration is an important character in distinguishing the subdivisions of the system. The beds are usually quite soft and disintegrate very rapidly, forming a layer of mud several inches thick over a large part of the exposed surface. A moderately heavy rain starts the mud almost in streams.[a]

The thickness of the John Day series north of the southern portion of the Blue Mountains is placed by Dr. Merriam between 1,500 and 2,000 feet, while to the south, in the vicinity of Logan Butte, it is estimated to be between 3,000 and 4,000 feet.

The John Day series is divided by Dr. Merriam into a lower, middle, and upper division. The lower division, having an estimated thickness of 250 or 300 feet, consists of—

> highly colored shale which breaks down readily, forming characteristic mud-covered domes. These beds are in the main a deep red, with occasional alternating strata of buff or white ash. At Bridge Creek alternating beds of red, white, and green, occurring in a group of typical hills of this division, form a striking feature of the landscape, the colored strata making sharply-defined rings about the hills.[b]

The middle division, having a thickness of from 500 to possibly 800 or 1,000 feet—

> consists of drab to bluish-green beds, sometimes forming rounded hills, but more frequently exposed as steep, pinnacled, and ribbed bluffs.[c]

The uppermost beds, showing a thickness of 300 or 400 feet, or in some cases of somewhat more, are—

> buff, tufaceous, or ashy deposits, sometimes with sand and gravels near the top. . . . . They are usually harder and are generally exposed as steeper bluffs than the strata of the lower divisions.[d]

The lower division of the John Day series is practically barren of fossils of all kinds, while the middle and upper divisions have furnished a very extensive fauna. The only plant remains, with possibly a single exception, are found in the upper division, and even here they consist of only four or five species. The locality is 3½ miles south of Lone Rock.

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[a] Merriam, op. cit., p. 292. [b] Idem, p. 293. [c] Idem, p. 294. [d] Idem, p. 295.

COLUMBIA RIVER LAVA.

So far as can now be made out the great Columbia River lava once covered practically the entire John Day country, with few, if any, points projecting above it. It consists of a large number of basalt flows which are sometimes separated by beds of tuff, and it is estimated by Dr. Merriam to be not less than 1,000 feet in thickness, and in many cases it seems to be still thicker. This lava sheet has been comparatively little disturbed, remaining practically flat over the entire region, being rarely inclined more than 5° or 10°.

MASCALL FORMATION.

At several points within the basin there is a series of sediments resting upon the Columbia River lava to which Dr. Merriam has given the name Mascall formation. This series, or portions of it, has been variously known in literature as the Cottonwood beds, Loup Fork beds, the Ticholeptus beds, the Amyzon beds in part, and finally the Protolabis beds. For one reason or another these various terms are inapplicable. Thus "Cottonwood" is preoccupied by its use for a Carboniferous formation in Kansas; its correlation with the Loup Fork, the Amyzon beds, and the Ticholeptus beds is open to doubt, leaving only Wortman's term, Protolabis beds, which, in Dr. Merriam's opinion, will cover only a portion of the section. The name Mascall formation was suggested by the occurrence of the typical section near the Mascall ranch, 4 miles below Dayville.

> At Rattlesnake Creek, near Cottonwood, the Mascall is not less than 800 to 1,000 feet thick. The beds are made up largely of ash and tuff, and are generally light colored, though there are some brownish and reddish strata. Coarse, detrital materials are generally absent from the typical section.[a]

The Mascall formation has afforded a large and varied fauna, consisting of mammals, testudinates, and fish, and a large and interesting flora. The Van Horn's or Belshaw's ranch locality is in this formation, occurring near the base of the section. The plants are preserved in a soft, white, fine-grained ash or tuff, which is often 10 feet in thickness, though usually less. This material is so light when dry that it readily floats for some time on water.

RATTLESNAKE FORMATION.

Dr. Merriam has given the name Rattlesnake formation to a series of coarse gravels, tuffs, and rhyolite flows that rest unconformably upon the Mascall formation. These beds are very slightly inclined, showing a dip of only about 5°.

[a] Merriam, op. cit., p. 307.

. . . . At one locality on Birch Creek, where a section of the Rattlesnake was carefully examined, it was found to comprise 30 to 40 feet of coarse basal gravels, above this about 25 feet of soft brown tuff, and capping this about 30 feet of rhyolite. At other localities more than 100 feet of gravel have been seen upon the rhyolite. The basal gravel beds show a thickness of 200 feet or more in other localities. They are frequently very coarse and contain many pebbles, evidently derived from the Columbia [River] lava.[a]

The Rattlesnake formation has therefore not yielded fossil plants, but contains a considerable vertebrate fauna.

RIVER TERRACES.

At many places along the John Day and its tributaries "one or more terraces are to be found not far above the existing floor of the valley." In several localities they have been found to contain undisturbed remains of *Elephas primigenius*.

LOCALITIES FOR FOSSIL PLANTS IN THE JOHN DAY BASIN.

1. BRIDGE CREEK, about 6 miles southeast of Burnt ranch and 2½ miles southwest of The Dalles military road at Allen's ranch. Collections at this place have been made by Condon, Voy, Bendire, Merriam, Osmont, and Knowlton.

2. ROAD CROSSING AT CHERRY CREEK, about 10 miles northwest of Burnt ranch. Collections made by Merriam's party in 1900 and by Knowlton and Merriam in 1901. The original locality which afforded the specimens studied by Lesquereux and Newberry is said to be about 2 miles up Cherry Creek from the point where the military road first crosses it.

3. CURRANT CREEK, CROOK COUNTY. Several species were described by Newberry from collections made by Condon at this locality. Only one of these species has been since obtained in this area and then not at the original place, but at Cherry Creek. The type locality is unknown.

4. ONE AND ONE-HALF MILES EAST OF CLARNOS FERRY. Collection made by Merriam's party in 1900.

5. THREE MILES ABOVE CLARNOS FERRY. Collection made by Merriam's party in 1900.

6. ONE-HALF MILE NORTHEAST OF FOSSIL. Collection made by Merriam's party in 1900.

7. THREE AND ONE-HALF MILES SOUTH OF LONE ROCK. Collection made by Merriam's party in 1900.

8. VAN HORN'S RANCH (now Belshaw's ranch), about halfway between Canyon and Dayville, on East Fork of John Day River. Original locality south side of military road and near bed of stream. Collections made by Condon, Voy, Bendire, Merriam, and Knowlton and Merriam.

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[a] Merriam, op. cit., p. 310.

9. BELSHAW'S RANCH, at white hill about one-half mile northeast of original locality and on north side of military road. Collections made probably by Bendire and by Knowlton and Merriam.

10. BELSHAW'S RANCH, in gulch 1 mile northeast of Belshaw's house and about 2 miles east of original locality. Collection made by Knowlton and Merriam.

11. OFFICER'S RANCH, one-fourth mile from John Day River, lower end of Butler Basin (Butler Basin = upper end of Turtle Cove). Collection made by Merriam, July 22, 1901.

12. FOUR MILES EAST OF DAYVILLE, south side of East Fork Valley. Collection made by Merriam's party in 1900.

SYSTEMATIC DESCRIPTION OF SPECIES.

Family SCHIZÆACEÆ.

LYGODIUM KAULFUSII Heer.

LYGODIUM KAULFUSII Heer. Newberry, Later Extinct Floras, p. 1, Pl. LXII, figs. 1–4, 1898.

Lygodium neuropteroides Lesq., Tert. Fl., p. 61, Pl. V, figs. 4–7; Pl. VI, fig. 1, 1878; Proc. U. S. Nat. Mus., Vol. XI, p. 24, 1888.

As it now seems pretty generally agreed that Lesquereux's *Lygodium neuropteroides* is the same as *L. Kaulfusii* of Heer, all the Oregon material has been so referred.

The material from Cherry Creek collected by Major Bendire embraces some forty more or less perfect examples.[a] The expedition of the University of California of 1900 obtained four examples of this species at Cherry Creek in a matrix corresponding to that first mentioned above, and a number of additional specimens were obtained by Dr. Merriam and myself at the same place in 1901.

Locality.—Cherry Creek, Crook County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2505), by Merriam's party in 1900 (Mus. Univ. Cal., Nos. 176, 177, 183, 224), and by Knowlton and Merriam in 1901 (U. S. Nat. Mus., Nos. 9059–9066).

Family POLYPODIACEÆ.

ASPLENIUM SUBSIMPLEX (Lesq.) Knowlton.

ASPLENIUM SUBSIMPLEX (Lesq.) Knowlton, Cat. Cret. and Tert. Pl. N. A., p. 45, 1898.

Pteris subsimplex Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 24, 1888.

There are fragments of several fronds in the collection that should probably be referred to this species, yet they do not quite agree in all particulars. Thus the example secured by Bendire (U. S. Nat. Mus.,

[a] As already pointed out (ante p. 13) the material in the United States National Museum under this number appears to consist of two very distinct lots. Only those known to have come from Cherry Creek are here referred to.

No. 2634) has the frond from 4.5 cm. to nearly 5 cm. in width, while a specimen obtained by the University of California (No. 170, counterpart 171) is only 2.5 cm. in width. These measurements are larger and smaller respectively than the usual examples of *A. subsimplex* from Colorado, and the nervation arises at a less angle in the Oregon specimen, but these differences are slight and probably not sufficient to exclude them from this species.

Locality.—Cherry Creek, Crook County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2634), by Merriam's party in 1900 (Mus. Univ. Cal., Nos. 170, 174), and by Knowlton and Merriam, 1901 (U. S. Nat. Mus., Nos. 9068–9074).

PTERIS PSEUDO-PINNÆFORMIS? Lesq.

PTERIS PSEUDO-PINNÆFORMIS Lesq., Tert. Fl., p. 52, Pl. IV, figs. 3, 4, 1878.
Pteris pinnæformis Heer. Newberry, Later Extinct Floras, p. 7, Pl. XLVIII, fig. 5, 1898.

This species appears to have been found but once. The specimen is now in the United States National Museum and is preserved in matrix which closely resembles that at Cherry Creek.

Locality.—Currant Creek, Oregon. Collected by Rev. Thomas Condon (U. S. Nat. Mus., No. 8098).

LASTREA (GONIOPTERIS) FISCHERI? Heer.

LASTREA (GONIOPTERIS) FISCHERI Heer, Fl. Tert. Helv., Vol. I, p. 34; Pl. IX, figs. 3a–3e, 1855; Newberry, Later Extinct Floras, p. 10, Pl. XLVIII, fig. 6, 1898.
Lastrea Knightiana Newb., Proc. U. S. Nat. Mus., Vol. V, p. 503, 1883.

The specimen upon which this determination was based is in the United States National Museum, and so far as known no others have since been obtained.

Locality.—Currant Creek, Oregon. Collected by Rev. Thomas Condon (U. S. Nat. Mus., No. 7097).

Family EQUISETACEÆ.

EQUISETUM OREGONENSE Newb.

EQUISETUM OREGONENSE Newb., Proc. U. S. Nat. Mus., Vol. V, p. 503, 1883; Later Extinct Floras, p. 14, Pl. LXV, fig. 7, 1898.
Equisetum Hornii Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 23, 1888.

After a careful examination of the forty or more specimens of Lesquereux's *E. Hornii* I am convinced that they are the same as Newberry's *E. oregonense.* They are better preserved than Newberry's material, many of them not being compressed in the least. Two or three flat specimens have a width of fully 3 cm., and the non-compressed examples range from 1.25 cm. to over 1.5 cm. in diameter. Several of the diaphragms are preserved without distortion. They are from 1.25 to 2 cm. in diameter and evidently several millimeters

in thickness. The sheaths are short and provided with short, obtuse dentations. The teeth are nearly obsolete. The number of striations, as nearly as can be made out, is between forty and fifty.

Localities.—Currant Creek, Oregon. Collected by Rev. Thomas Condon (type of *E. oregonense*, which is in Mus. Columbia Univ., N. Y.). Cherry Creek, Crook County, Oregon. Collected by Maj. Charles E. Bendire (type of *E. Hornii*, U. S. Nat. Mus., No. 2464, 41 specimens); by Merriam's party in 1900 (Mus. Univ. Cal., Nos. 184, 185, 922), and by Knowlton and Merriam in 1901 (U. S. Nat. Mus., No. 9067). Also 3 miles above Clarnos Ferry. Collected by Merriam's expedition of 1900 (Mus. Univ. Cal., Nos. 184, 185, 910, 922).

Equisetum sp.

Pl. I, fig. 1.

The collection contains a small fragment that appears to represent a short portion of the stem and a single sheath of an Equisetum. The stem is about 0.5 cm in diameter, while the sheath is about 8 mm. long and 4 mm. broad at the upper extremity. It is not well enough preserved to show the full character of the sheath, but as nearly as can be made out it was provided with about 16 ribs and presumably an equal number of sharp teeth.

Locality.—Gulch 1 mile northeast of Belshaw's ranch, Grant County, Oregon. Collected by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., No. 8503).

Family GINKGOACEÆ.

Ginkgo sp.

Pl. I, fig. 5.

The collection contains a fragment of what appears to be a leaf of Ginkgo, but it is too much broken to make out any of the essential characters. The most that can be said is that it must have been a large leaf as compared with the living species.

Locality.—Mascall beds, Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by John C. Merriam, July, 1901 (U. S. Nat. Mus., No. 8536).

Family PINACEÆ.

Sequoia Heerii Lesq.

Sequoia Heerii Lesq., Tert. Fl., p. 77, Pl. VII, figs. 11-13, 1878; Newberry, Later Extinct Floras, p. 20, Pl. XLVII, fig. 7, 1898.

In the Later Extinct Floras there is a fine figure of this species, but according to the note by the editor, Dr. Hollick, there was no clew to the locality whence the specimen came. The original is not now in

the collection of the United States National Museum, so it is impossible to compare the matrix with that from Bridge Creek, but in the material from this locality obtained by Major Bendire there is a fine specimen that is absolutely the same as Lesquereux's type (U. S. Nat. Mus., No. 60) from Sage Creek, Montana. It is also identical with the figure given by Newberry, and as this species has never before been found outside of the type locality it is more than probable that Newberry's specimen was from Bridge Creek.

Locality.—Bridge Creek, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 9220).

Sequoia angustifolia Lesq.

Sequoia angustifolia Lesq., Cret. and Tert. Fl., p. 240, Pl. L, fig. 5, 1883.
Sequoia Nordenskiöldii Heer. Lesquereux, Proc. U. S. Nat. Mus., Vol. XI, p. 19, 1888.

The Mascall beds at Van Horn's ranch contain a large number of specimens that are undoubtedly the same as Lesquereux's *Sequoia angustifolia* from Corral Hollow, San Joaquin County, California. Whether the California material is identical with the original material[a] from Elko, Nevada, I am not prepared to say, as the types are not at hand for comparison, but a large number of specimens obtained during the past season at Elko by Prof. George C. Lawson, of the University of California, are absolutely indistinguishable from the specimens as figured by Lesquereux. Such of this material as passed through Lesquereux's hands was referred by him to *Glyptostrobus Ungeri* with the exception of a single undoubtedly similar example, which was placed under *Sequoia Nordenskiöldii* as set forth in the above synonymy. This can not be properly referred to American specimens of *Glyptostrobus Ungeri*, although, as I have stated on several occasions,[b] the status of this form is at present unsatisfactory.

In seeking for affinities for these Oregon specimens I have compared most of the figures of conifers given by Heer in his Flora Fossilis Arctica and other publications, and I am forced to the conclusion that there has been more or less confusion in dealing with these forms. Thus I am not able to distinguish what is called by Heer *Glyptostrobus europæus* from the Baltic Miocene[c] from the Van Horn's ranch specimens, and what seems to be the same species or something very close to it is called *Taxodium Tinajorum* Heer[d] from the Miocene of Spitzbergen. The whole subject of the Tertiary conifers, especially of northern and arctic lands, is much in need of revision, and pending this the form under discussion may be referred to Lesquereux's *Sequoia angustifolia* as typified from Corral Hollow, California.

In the original description *S. angustifolia* is characterized as follows: "Leaves short, narrow, linear pointed, erect or slightly

[a] See Tert. Fl., p. 77, Pl. VII, figs. 6-10, 1878.
[b] Cf. Cat. Cret. and Tert. Pl. N. A., p. 113.
[c] Mioc. Balt. Fl., Pl. III, figs. 8, 9.
[d] Fl. Foss. Arc., Vol. II, Abth. 3, Pl. IV, figs. 6, 29, etc.

appressed all around the branches, decurring at base." This in the Tertiary Flora is amended to read: "Branchlets short, slender; leaves at unequal distances, sometimes very close, two or three together, or very distant, often dimorphous, linear lanceolate, taper pointed, open or curved backward, decurrent; middle nerve indistinct." In the discussion in the latter book Lesquereux emphasizes the fact that the leaves are "decurrent but not narrowed at base."

All things considered this description agrees well with the specimens from Oregon, but the material from Elko, obtained during the summer of 1901 and presumably at or near the type locality, shows a slight narrowing of the leaves at the base and a tendency to be less acute at the apex.

Locality.—Mascall beds, Van Horn's ranch and vicinity, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2610), and by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., Nos. 9029–9033).

SEQUOIA LANGSDORFII (Brgt.) Heer.

SEQUOIA LANGSDORFII (Brgt.) Heer. Lesquereux, Proc. U.S. Nat. Mus., Vol. XI, p. 19, 1888.

Taxodium distichum miocenum Heer. Newberry, Later Extinct Floras, p. 22, Pl. XLVII, fig. 6, 1898.

The collections contain a number of examples that undoubtedly belong to this species, although some of them do not agree in all particulars with certain of the published figures. The branchlets are rather small, with small leaves, but the latter are distinctly decurrent, after the manner of *S. Langsdorfii.*

The Bridge Creek material, which passed through the hands of Newberry, was identified by him as *Taxodium distichum miocenum*, but absolutely similar material was referred by Lesquereux to *Sequoia Langsdorfii*, and I believe correctly so.

This species, although not especially abundant at any locality in the John Day Basin, is widely distributed, as may be seen from the following list of localities:

Localities.—Bridge Creek. Collected by Rev. Thomas Condon (U. S. Nat. Mus., No. 7086), by Maj. Charles E. Bendire (U. S. Nat. Mus., Nos. 9236, 9281, 9285, 9303, 9314, 9330, 9376), and by Knowlton and Merriam. One and one-half miles east of Clarnos Ferry. Collected by Merriam's expedition of 1900 (Mus. Univ. Cal., Nos. 896, 907, 914.) One and one-half miles northeast of Fossil. Collected by Merriam's expedition of 1900 (Mus. Univ. Cal., Nos. 925, 927, 929). Three and one-half miles south of Lone Rock. Collected by Merriam's expedition of 1900 (Mus. Univ. Cal., No. 1339). Mascall beds, Van Horn's ranch and vicinity. Collected by Major Bendire (U. S. Nat. Mus., No. 2607), and by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., Nos. 8958–8960).

SEQUOIA sp. (Cone).

Pl. I, fig. 2.

The original collection contains a large cone that was referred by Lesquereux to *Sequoia Langsdorfii*, but it does not appear to agree in size with the cones usually assigned to that species. This cone is a little more than 2.5 cm. in length and nearly 2 cm. thick, and stands on a thick peduncle 7 mm. long and nearly 3 mm. thick. It has been much crushed, and the shape of the scales can not be made out with certainty. In general appearance, however, it seems to belong to Sequoia, but the species must remain uncertain.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 8510).

THUITES sp.

Pl. I, fig. 3.

Branchlets slender, alternate, leaves thickish, 4-ranked, imbricated, the lateral ones broad-deltoid, rather obtuse pointed, others apparently broader and more obtuse, obscurely carinate on the back.

The little fragment figured is all that has been thus far found in the collections. The branchlets appear to be alternate and slender. As nearly as can be made out, the leaves are 4-ranked and very thick, with obtuse apices.

This form does not differ greatly from *T. Ehrenswærdi* Heer,[a] from the Miocene of Sachalin, and Spitzbergen.

This has slender, alternate branchlets and thick 4-ranked leaves. They are more strongly carinate on the back than ours, but otherwise there is no marked difference. As the branchlets from Oregon are so small and not very well preserved, I have hesitated to identify them with Heer's species, although they may all be the same.

Locality.—Van Horn's ranch, 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Merriam's expedition of 1900 (Mus. Univ. Cal., No. 879).

GLYPTOSTROBUS UNGERI Heer.

GLYPTOSTROBUS UNGERI Heer. Lesquereux, Proc. U. S. Nat. Mus., Vol. XI, p. 19, 1888.

Sequoia Nordenskiöldii Heer. Lesquereux, op. cit., p. 19.

The collection contains numerous specimens that are referred to this species. As I have pointed out on several occasions, there is more or less confusion regarding the proper fixing of the limits of this species. It is apparent that there is or has been a mixing of this with what has

[a] Fl. Foss. Arct., Vol. II, p. 36, Pl. II, figs. 25, 26, 1870; idem, Vol. V, Abth. 4, p. 23, Pl. I, figs. 12-14, 1878.

been called *G. europæus*, *Sequoia Couttsiæ*, etc., but we have not a sufficient amount of authentic material to enable us to settle the question.

The single specimen with its counterpart (U. S. Nat. Mus., No. 2610), referred by Lesquereux to *Sequoia Nordenskiöldii*, is undoubtedly the same as what is here called *Glyptostrobus Ungeri*.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., Nos. 2480, 2610) and by Merriam's expedition of 1900 (Mus. Univ. Cal., Nos. 863, 872–882).

TAXODIUM DISTICHUM MIOCENUM Heer.

The collections embrace a dozen or more branchlets that I am constrained to refer to this form. They do not agree perfectly with certain figures of this species, but the differences are slight, and they had best be placed here. Unless material is very perfectly preserved it is difficult to determine the exact manner of the insertion of the leaves, and such is the case with these specimens.

Locality.—Mascall beds, Van Horn's ranch, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2614) and by Merriam's expedition of 1900 (Mus. Univ. Cal., No. 878a).

TAXODIUM, male aments of.

Pl. I, figs. 4, 6.

In the material from the Mascall beds are two specimens, both of which are here figured, that appear to represent the male aments of Taxodium. They are long, slender, and clustered, with the aments on short lateral spurs. They are hardly to be distinguished from the aments of the living *Taxodium distichum*, and in all probability belonged to *T. distichum miocenum*, which is not uncommon in these beds.

Locality.—Mascall beds, Van Horn's ranch, Oregon. Larger specimen (fig. 4) collected by Merriam's expedition of 1900 (type in Mus. Univ. Cal., No. 889). Other example (fig. 6) collected by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., No. 8551).

Family GRAMINEÆ.

PHRAGMITES ŒNINGENSIS Al. Br.

PHRAGMITES ŒNINGENSIS Al. Br. Lesquereux, Proc. U. S. Nat. Mus., Vol. XI, p. 19, 1888.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2530).

Family CYPERACEÆ.

CYPERACITES sp.

Pl. I, fig. 9.

The collection contains a single specimen that appears to be the leaf of a large cyperaceous plant. It is about 1 cm. in width and has about 10 ribs or striæ through it, but there is hardly enough to afford any characters of importance, and it is included simply to show that this type of vegetation was present.

Locality.—Mascall beds, Van Horn's ranch, 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., No. 8542).

Family SMILACEÆ.

SMILAX WARDII Lesq.

SMILAX WARDII Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 19, Pl. XIII, fig. 1, 1888.

The type specimen, with its counterpart, is all that has ever been obtained.

Locality.—Van Horn's ranch, South Fork of John Day River, 12 miles west of Mount Vernon, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2613).

MONOCOTYLEDONOUS PLANT.

Pl. I, figs. 7, 8.

Among the collections lately obtained by the University of California I found two examples of what are undoubtedly monocotyledonous plants, the nature of which I am at present unable to satisfactorily describe. They are shown as well as possible in the accompanying figures.

The one shown in fig. 7 is about 6.5 cm. in length, as now preserved, and 1.5 cm. in width. It is bifurcate at apex into two nearly equal, acute lobes. It is provided with some 8 or 9 longitudinal ribs, separated by rather deep channels.

The other, shown in fig. 8, is rather elliptical-lanceolate in shape and is apparently acuminate at apex, but the extreme point and the base are not preserved. It is the same length as the other, but is a little wider, being 1.75 cm. It is likewise provided with 8 or 9 ribs, between which are numerous finer striæ or veins. The basal end is truncated, as though it was a sheathing organ of some kind.

In general appearance these specimens, and especially the one last mentioned, are at least suggestive of what Lesquereux[a] has described

[a] Tert. Fl., p. 28, Pl. I, figs. 10, 11, 1878.

as *Podozamites oblongus*, from the Dakota group of Kansas, but this is without the prominent ribs seen in our specimens. This resemblance can hardly be more than superficial, and we must await future material before the status of these specimens can be definitely settled.

Locality.—Bridge Creek, Oregon. Collected by Merriam's party of 1900 (types in Mus. Univ. Cal., Nos. 2500, 2501).

Family SALICACEÆ.

Populus Lindgreni Knowlton.

Pl. II, fig. 1.

Populus Lindgreni Knowlton, Eighteenth Ann. Rept. U. S. Geol. Surv., Pt. III, p. 725, Pl. C, fig. 3, 1898.

The collections from near Van Horn's ranch, made during the season of 1901 by Dr. Merriam and myself, contain a single very perfectly preserved leaf that must be referred to this species. It differs slightly from the type in being more nearly circular in shape, but in matter of size, marginal teeth, and nervation the two specimens are identical.

Locality.—White hill one-half mile east of original Van Horn's ranch locality, Grant County, Oregon. Collected by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., No. 8512). Type specimen from 2 miles southeast of Marsh post-office, Boise County, Idaho (U. S. Nat. Mus., No. 8292).

Salix Schimperi Lesq.

Salix Schimperi Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 21, Pl. XIII, fig. 5, 1888.

Locality.—Cherry Creek, Crook County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2595).

Salix Engelhardti Lesq.

Salix Engelhardti Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 17, Pl. VIII, fig. 2, 1888.
Cassia phaseolites? Ung. Lesquereux, idem., p. 16.

It seems doubtful if this is correctly referred to Salix, but as no new material except a specimen to be mentioned below has come to light, it may be best to retain it as left by its author.

It was observed that the single example referred by Lesquereux to *Cassia phaseolites?* Ung. had a serrate margin, which would exclude it from this genus, and a further comparison convinces me that it is another leaf of *Salix Engelhardti.* It is a small leaf, not quite so broad relatively in the upper part, but it has a base of the same shape, the same serrate margin, and the same nervation as this species, and is therefore referred to it. It becomes then the second known specimen of *S. Engelhardti.*

Locality.—Van Horn's ranch, South Fork of John Day River, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., Nos. 2455, 2589.)

SALIX RÆANA? Heer.

SALIX RÆANA? Heer. Lesquereux, Proc. U. S. Nat. Mus., Vol. XI, p. 17, 1888.

It is extremely doubtful if this is correctly identified, as the specimen upon which it is based is very poor, but as no other example has been found it may remain as above. Little weight should be attached to it, however.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2594).

SALIX VARIANS Göppert.

SALIX VARIANS Göppert. Lesquereux, Proc. U. S. Nat. Mus., Vol. XI, p. 17, 1888.

I regard this identification as more or less doubtful. It is smaller than the usual form of this species, although similar in size and appearance to a leaf so determined by Heer[a] from Alaska. It is the only example found.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2596).

SALIX ANGUSTA Al. Br.

SALIX ANGUSTA Al. Br. Lesquereux, Cret. and Tert. Fl., p. 247, Pl. LV, fig. 6, 1883.

These are two narrow leaves that agree closely with the smaller figures given by Lesquereux as above quoted. The locality is stated to be "Oldfield claim, Oregon," but I have been unable to further identify the place. The type specimen is preserved in the paleontological collection of the University of California (No. 1963), and the leaves under consideration appear to be the same as the leaves from this unknown locality in Oregon. It does not follow, however, that they should be regarded as identical with all leaves that have been referred to this species from other localities.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Merriam's expedition of 1900 (Mus. Univ. Cal., Nos. 85, 87.)

SALIX AMYGDALÆFOLIA Lesq.

SALIX AMYGDALÆFOLIA Lesq., Cret. and Tert. Fl., p. 156, Pl. XXXI, figs. 1, 2, 1883.
Proc. U. S. Nat. Mus., Vol. XI, p. 17, 1888.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2587).

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[a] Fl. Foss. Alask., p. 27, Pl. II, fig. 8, 1869.

SALIX PSEUDO-ARGENTEA n. sp.

Pl. II, figs. 2–4.

Sapindus angustifolius Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 15, 1888.

Leaves of firm texture, lanceolate or narrowly ovate-lanceolate in shape, narrowed about equally to both base and apex; margin perfectly entire; petiole short, rather slender; midrib rather strong; secondaries numerous, some 12 or 15 pairs, at an acute angle, thin and nearly concealed in the substance of the leaf, camptodrome; finer nervation not preserved.

I refer a large number of specimens to this form, among them one that was identified by Lesquereux as *Sapindus angustifolius*. They are mainly small, narrow leaves from 4 to 6 cm. in length and from 1 to 1.5 cm. in width. The petiole is 5 mm. long, and, as stated above, slender for the size of the leaf. This form has a close resemblance to the living *Salix argentea*.

Locality.—Mascall beds, Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., Nos. 8527, 8528, 8529).

SALIX DAYANA n. sp.

Pl. II, figs. 9, 10.

Leaves of firm texture, ovate-lanceolate or elliptical-lanceolate, truncate or slightly heart-shaped at base, acuminate at apex; margin perfectly entire; petiole very short, stout; midrib thick; secondaries, 10 or 12 pairs, at an angle of about 40°, thin and obscure, camptodrome, arching and joining well inside the margin; finer nervation not retained.

I refer three examples to this form, two of which are here figured. The smaller is 4.5 cm. long and 1.5 cm. wide, the larger 5.5 cm. long and nearly 2 cm. wide. The petiole is about 2 mm. long.

Locality—Mascall beds, Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., Nos. 8530, 8531).

SALIX PERPLEXA n. sp.

Pl. II, figs. 5–8.

Leaves of firm texture, obovate-lanceolate to elliptical-lanceolate in shape, narrowed, often abruptly, to the petiole, rather obtuse at apex; margin entire; petiole short; midrib strong below, becoming very thin above; secondaries numerous, 12 or 15 pairs, alternate, at a low angle, parallel, effaced near the margin, but apparently camptodrome; finer nervation obscure, but apparently producing very fine areolæ.

This form is represented by a dozen or more examples, among which there is a considerable range in size. The smallest leaves are only 2.25 cm. in length and 13 mm. in width, while the larger are nearly 5 cm. in length and 1.75 cm. in width. The average size is about 3.5 cm. in length and 1.75 cm. in width. The petiole is 5 or 6 mm. long.

This species is certainly similar in general appearance to certain forms of *Salix Bebbiana*, a species now widely distributed throughout the Rocky Mountain area.

Locality.—Mascall beds, Van Horn's ranch and vicinity, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., Nos. 8521, 8522, 8523, 8524).

SALIX MIXTA n. sp.

Pl. II, figs. 11, 12.

Leaves coriaceous in texture, ovate-lanceolate or ovate-elliptical in shape, slightly unequal-sided, subcordate or abruptly rounded at base; margin finely and evenly serrate; midrib thick; secondaries numerous, rather close, parallel, emerging at a low, almost right, angle, curving upward near the margin, strongly camptodrome, or occasionally with a secondary passing to the margin; when camptodrome arching well inside the margin with fine nervilles passing to the teeth; nervilles numerous, mainly broken, at an oblique angle; finer nervation forming a very regular fine mesh.

This form is represented by about a dozen examples, many of which are quite perfect. The longest appear to have been about 8 cm. in length and the smallest about 4 cm. The width is about 2 cm. The petiole is not preserved in any case. The margin is uniformly serrate. The secondaries are numerous, emerging nearly at a right angle on one side of the leaf and an angle of 20° or 30° on the other, all passing in the upper portion to an angle of about 45°. They are mainly camptodrome, but occasionally one passes directly to the margin.

These leaves undoubtedly belong to Salix and are so close to certain described forms that it is difficult to determine whether or not they should be regarded as new.

Locality.—Mascall beds, Van Horn's ranch and vicinity, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., Nos. 8525, 8526).

SALIX sp. ? Knowlton.

Pl. III, fig. 1.

SALIX sp., Knowlton in Merriam, Univ. Cal., Bull. Dept. Geol., Vol. II, No. 9, p. 303. 1901.

A fragment that appears to belong to Salix. It is not sufficient to settle its identity.

Locality.—Three and one-half miles south of Lone Rock. Collected by Merriam's expedition of 1900 (Mus. Univ. Cal., No. 1343).

Family MYRICACEÆ.

MYRICA OREGONIANA n. sp.

Pl. III, fig. 4.

Leaf coriaceous, ovate-lanceolate, very unequal-sided at base, acuminate at apex; margin coarsely toothed, the teeth upward pointing, rather obtuse; petiole short, very strong; midrib strong, perfectly straight; secondaries, some 10 or 12 pairs, thin, arising at an angle of about 45°, straight, ending in the teeth; finer nervation obscure.

The very perfect example figured, with its counterpart, is all thus far detected of this form. It is rather broadly ovate-lanceolate in shape, cordate on one side at base and very oblique on the other side. The apex is acuminate. The length is 3.5 cm. exclusive of the petiole, which is 3 mm. long, and the width is 1.4 cm. The margin is very coarsely toothed.

This species is nearest to *Myrica callicomæfolia* Lesq.,[a] found abundantly at Elko station, Nevada, and Florissant, Colorado. It differs, however, in being relatively much shorter and broader, and in having much larger teeth, which are obtuse rather than flat and acute. The petiole is also relatively shorter and thicker.

Locality.—White hill, one-half mile east of original Van Horn's ranch locality. Collected by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., No. 8532).

MYRICA? PERSONATA n. sp.

Pl. III, fig. 2.

MYRICA n. sp., Knowlton in Merriam, Univ. Cal., Bull. Dept. Geol., Vol. II, No. 9, p. 290, 1901.

Leaf membranaceous, narrowly lanceolate in shape, wedge-shaped at base and apparently acuminate at apex; margin coarsely and sharply serrate; midrib very thick, straight; secondaries numerous, about 16 or 18 pairs, alternate, emerging at a low to nearly an angle of 45° in the upper portion of the blade, somewhat curving upward and ending in the teeth, occasionally forking before passing to the teeth; nervilles strong, percurrent, at right angles to the secondaries; finer nervation producing rectangular areas.

The example figured unfortunately lacks portions of both base and apex, but it is the only fragment thus far obtained. It was apparently about 8 or 9 cm. long and is exactly 2 cm. wide. It appears wholly unlike anything previously described from this area.

Locality.—One-half mile northeast of Fossil, Gilliam County, Oregon. Collected by Merriam's party of 1900 (type No. 924 in Mus. Univ. Cal.).

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[a] Cret. and Tert. Fl., p. 146, Pl. XXVI, figs. 5-14.

Family JUGLANDACEÆ.

JUGLANS RUGOSA Lesq.

JUGLANS RUGOSA Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 22, 1888.

Represented by two fragments that are more or less obscure and doubtful. There is also a single fragment obtained by the expedition of the University of California of 1900.

Locality.—Cherry Creek, Crook County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2489) and by Merriam's party of 1900 (Mus. Univ. Cal., No. 188).

JUGLANS? BENDIREI n. sp.

Pl. III, fig. 3.

Ilex? longifolia Heer. Lesquereux, Proc. U. S. Nat. Mus., Vol. XI, p. 21, 1888.

Leaflet coriaceous in texture, lanceolate, apparently wedge-shaped at base and acuminate at apex; margin irregularly and rather obscurely toothed; midrib very thick, straight; secondaries numerous, rather close, about 20 pairs, alternate, at an angle of about 45°, somewhat arching upward, camptodrome, arching near the margin and each joining the one next above by a thin branch, with their nervilles on the outside passing to the marginal teeth; nervilles numerous, percurrent, at right angles to the secondaries; finer nervation producing a close areolation.

This particular specimen, as noted above, was referred to *Ilex longifolia* Heer, a species from the Miocene of Piedmont, but a comparison with the figure given by Heer shows that it is undoubtedly different. The original seems to have been a much shorter leaf, and while the Oregon specimen resembles it in a general way, there are important differences. The teeth are different, the secondaries more numerous, and the finer nervation is of a totally different character.

The question of the proper generic reference of this leaf or leaflet is an open one. It is not greatly unlike things that have been variously referred to Ilex, Quercus, and Juglans, but on the whole seems to have closest relationship with the latter. It will, however, need more and better material to settle the matter definitely.

Locality.—Cherry Creek, Crook County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 8545, on same stone with 2424).

JUGLANS SCHIMPERI? Lesq.

JUGLANS SCHIMPERI Lesq., Tert. Fl., p. 287, Pl. LVI, figs. 5–10, 1878.

A single example that seems to be identical with this species, yet as the specimen is broken and is the only one, I have preferred to question it.

Locality.—Bridge Creek, Grant County, Oregon. Collected by Merriam's expedition of 1900 (Mus. Univ. Cal., No. 196).

JUGLANS ACUMINATA? Al. Br.

Pl. III, fig. 5.

JUGLANS ACUMINATA? Al. Br., Neues Jahrb., 1845, p. 170.

The Bendire collection contains a single example that was referred by Lesquereux to this species. It does resemble this, but may not be the same.

Locality.—Bridge Creek, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 3006).

JUGLANS CRYPTATA n. sp.

Pl. VI, figs. 4, 5.

Leaflets membranaceous, broadly lanceolate, narrowed and unequal-sided at base, apparantly acuminate at apex; margin denticulate throughout, the teeth short, rather blunt; midrib very thick; secondaries numerous, 15 or more pairs, thin, alternate, close below, more remote above, mostly camptodrome and sending fine branches from the outside to the teeth; nervilles mainly percurrent and at right angles to the secondaries.

This form is represented by three leaflets, none of which is quite perfect. The largest, which is not figured, was probably about 14 cm. long and is 5 cm. wide at a point evidently some distance above the middle. The one next in size, shown in fig. 4, was 13.5 cm. long and is 3.5 cm. wide. The smallest one, shown in fig. 5, is about 10 cm. long and a little more than 2.5 cm. in width. Neither base nor apex is preserved in any case.

This species appears to find its greatest affinity with *Juglans Crossii* Knowlton,[a] from Green River, Wyoming, and other localities. The leaflets, however, are smaller, relatively narrower, less unequal-sided, and are toothed on both sides.

Locality.—Bridge Creek, Oregon. Collected by Merriam's expedition in 1900. Types in Mus. Univ. Cal., Nos. 2502, 2503.

JUGLANS, nut of.

This is clearly a nut of Juglans, but the specimen is not well enough preserved to permit of specific determination. Lesquereux, through whose hands this specimen once passed, was inclined to identify it doubtfully with *J. troglodytarum* Heer,[b] but it seems best not to venture giving it a name at present.

Locality.—Bridge Creek, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 8492).

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[a] Cat. Cret. and Tert. Pl. N. A., p. 122, 1888.
[b] Fl. Tert. Helv., Vol. III, p. 92, Pl. CXXVII, fig. 45, 1859.

JUGLANS CRASSIFOLIA n. sp.

Pl. IV, fig. 3.

Juglans n. sp., Knowlton in Merriam, Univ. Cal., Bull. Dept. Geol., Vol. II, No. 9, p. 303, 1901.

Leaflets thick in texture, lanceolate-acuminate in shape, rather abruptly narrowed at base; margin perfectly entire; midrib thick, rather strong; secondaries 9 to 12 pairs, strong, mainly alternate, at an angle of about 45°, much curving upward, camptodrome, passing near the margin and often joining the one next above; finer nervation nearly or quite obsolete.

This species is represented by a large number of leaflets, all more or less broken, preserved in a tangled mass on two or three pieces of matrix. The length is from 9 to 11 cm. and the width about 2.5 cm., with occasionally one somewhat smaller.

The affinity of this species is undoubtedly with certain of the forms of *J. Schimperi* Lesq.,[a] of the Green River group, being of the same size and shape as the figures quoted above, but different in having a less number of secondaries and a distinct finer nervation. These species are closely related and a larger series might show them to be identical.

Locality.—Three and one-half miles south of Lone Rock, Gilliam County, Oregon. Collected by Merriam's expedition of 1900 (Mus. Univ. Cal., Nos. 1326–1331).

JUGLANS OREGONIANA Lesq.

JUGLANS OREGONIANA Lesq., Foss. Pl. Aurif. Gravel, p. 35, Pl. IX, fig. 10, 1878.
Rhus Bendirei Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 15, 1888. (The small leaflet described.)
Juglans hesperia Knowlton, Eighteenth Ann. Rept. U. S. Geol. Survey, Pt. III, p. 723, Pl. XCIX, fig. 8, 1898.

This species was described by Lesquereux in his Flora of the Auriferous Gravels. As to the locality whence the type specimen came he says: "On soft laminated clay with *Aralia Whitneyi*, evidently of the same age as the Chalk Bluffs of California, without definite locality but Oregon." From these remarks it has been assumed that the specimen actually was from the Auriferous gravels, and that the label on it was wrong. Fortunately this type is preserved in the paleontological collection of the University of California (No. 1798), where I recently had opportunity of seeing it. It was at once seen that it was on the characteristic matrix of the Van Horn's ranch locality, and indeed the obscure labeling on the back of the specimen so indicates.

In both the older and more recent collections from Van Horn's ranch and vicinity I find a number of specimens, which I refer with

[a] Tert. Fl., p. 287, Pl. LVI, fig. 6, 1878.

little hesitation to *Juglans oregoniana*. Most of them are smaller than the type, being often only 7 cm. long and 2.5 cm. wide, although occasionally there is one that approaches it in size. In shape, marginal teeth, and nervation they are practically identical.

In 1888 Lesquereux[a] established his *Rhus Bendirei* on two specimens, one of which is figured and is to be taken as the type of the species. Regarding the other he says: "To these I refer a small oblong-lanceolate leaflet, rounded in narrowing rapidly to the point of attachment, very short petioled, with small teeth and areolation identical." This specimen (U. S. Nat. Mus., No. 2582) is identical with certain of the smaller leaflets of *Juglans oregoniana*, and is referred to it.

In my paper on the plants of the Payette formation of Idaho I ventured to describe,[b] under the name of *Juglans hesperia*, a fine, large leaflet. Attention was called at the time to the fact that it was very close to, if not identical with, *Juglans oregoniana*. Since that time I have again gone over the Payette material and have decided that the differences are not sufficient to warrant keeping them separate.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Type in Mus. Univ. Cal. collected by C. D. Voy. Obtained by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2582), Merriam's expedition of 1900 (Mus. Univ. Cal., No. 891), and by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., Nos. 9049, 9050, 9054). One mile northeast of Belshaw's ranch. Collected by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., Nos. 9043–9048). Two miles southeast of Marsh post-office, Boise County, Idaho (U. S. Nat. Mus., No. 8290).

HICORIA? OREGONIANA n. sp.

Pl. V, figs. 3, 4.

HICORIA n. sp., Knowlton in Merriam, Univ. Cal., Bull. Dept. Geol., Vol. II, No. 9, p. 289, 1901.

Leaflets subcoriaceous in texture, ovate-lanceolate, obtusely wedge-shaped and slightly unequal-sided at base, acuminate at apex; margin finely serrate, the teeth short, sharp; midrib thin, straight; secondaries numerous, about fifteen pairs, alternate and at somewhat irregular distances, thin, arising at various angles ($45^{\circ}\pm$) and considerably arching upward, craspedodrome, ending in the marginal teeth; nervilles numerous, thin, percurrent, about at right angles to the secondaries; finer nervation perfect, forming a fine, irregular network.

This is represented at present by two examples. One is 13 cm. long and 6 cm. wide, and the other is 12 cm. long and 5 cm. wide.

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[a] Proc. U. S. Nat. Mus., Vol. XI, p. 15, Pl. IX, fig. 2.

[b] Eighteenth Ann. Rept. U. S. Geol. Survey, Pt. III, p. 723, Pl. XCIX, fig. 8, 1898.

Locality.—Cherry Creek, Crook County, Oregon, collected by Merriam's expedition in 1900 (type in Mus. Univ. Cal., No. 172. Additional specimen, No. 190).

HICORIA sp?

Pl. V, fig. 2.

The single fragment figured is all that was found of this form. Lesquereux would call it *Hicoria* (*Carya*) *elænoides* (Ung.) Knowlton, but it seems too small a fragment on which to base a specific determination.

Locality.—Bridge Creek, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2978).

HICORIA ELÆNOIDES (Unger) Knowlton.

HICORIA ELÆNOIDES (Unger) Knowlton, Cat. Cret. and Tert. Pl. N. A., p. 117, 1898.
Carya elænoides (Unger) Heer. Lesquereux, Proc. U. S. Nat. Mus., Vol. XI, p. 18, 1888.

A single example that may be this species. It is oblong in shape, 2.25 cm. in long, and 1.5 cm. in short, diameter.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2446).

Family BETULACEÆ.

CARPINUS BETULOIDES Unger.

CARPINUS BETULOIDES Unger.

Locality.—Bridge Creek, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 8487).

CARPINUS GRANDIS? Unger.

CARPINUS GRANDIS Unger. Lesquereux, Proc. U. S. Nat. Mus., Vol. XI, p. 18, 1888.
Carpinus pyramidalis (Göpp.) Heer. Lesquereux, idem, p. 18, 1888.

The collection contains two specimens that are referred as above by Lesquereux, but they are rather obscure, one being without margin, and I have hesitated to recognize these species. They agree fairly well with *C. grandis* and may stand under this species until further material can be obtained.

Locality.—Mascall beds, Van Horn's ranch, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., Nos. 2439, 2440).

CORYLUS MACQUARRII (Forbes) Heer.

CORYLUS MACQUARRII (Forbes) Heer, Urwelt d. Schweitz, p. 321, 1865; Fl. Foss. Alask., Pl. IV, figs. 1-8, 1869; Newberry, Later Extinct Floras, Pl. XLVIII, fig. 4, 1898.

Among the large amount of material from Bridge Creek, I have seen but two imperfect examples that should be referred to this species.

One of these was figured by Newberry in his Later Extinct Floras (Pl. XLVIII, fig. 4) and the original is preserved in the United States National Museum (No. 7076), but no mention is made of the fact in the body of that work, although this information is given on the back of the specimen itself.

The other example was detected among the recent collections made by the University of California and is in its museum. Both of these specimens agree perfectly with the figures of this species given by Heer in his Flora Fossilis Alaskana (Pl. IV). There can be no question of their identity.

Locality.—Bridge Creek, Oregon. Collected by Rev. Thomas Condon (U. S. Nat. Mus., No. 7076) and by V. C. Osmont (Mus. Univ. Cal., No. 2504).

Betula heteromorpha n. sp.

Pl. III, figs. 6, 7; Pl. V, fig. 1.

Populus polymorpha Newb., in part, Proc. U. S. Nat. Mus., Vol. V, p. 506, 1883; Later Extinct Floras, p. 50, Pl. XLVI, fig, 3; Pl. XLVII, figs. 4, 8; Pl. XLIX, fig. 4, 1898 (not other figures).

Leaves of firm or subcoriaceous texture, ovate, elliptical, or very slightly elliptical-obovate in general outline, from very obtusely wedge-shaped to truncate or obscurely heart-shaped, and often unequal-sided base, obtusely acuminate at apex; petiole usually strong, one-half or less the length of the blade; margin usually coarsely and unequally dentate or sometimes doubly dentate, the teeth mainly obtuse, occasionally acute; midrib rather thick, especially in the lower part of the blade; secondaries 7 to 9 pairs, usually strong, the two or three lower pairs close together and at a lower angle than the others; upper ones at an angle of about 45°, often spreading and slightly curved downward, all craspedodrome and ending in the large teeth, and often with several branches on the lower side which pass to smaller teeth; nervilles numerous and strong, both percurrent and broken, approximately at right angles to the secondaries; finer nervation producing an irregular areolation.

This form is the most abundant one in the collections and is represented by hundreds of examples. They are in general small leaves, ranging in length from 4.5 to 7 cm., and average length being about 5 cm. In width they range from 2.5 to 5 cm., the average being perhaps a little more than 3 cm. Only occasionally is one noted that is a little smaller than the above dimensions (cf. Newberry, Later Extinct Floras, Pl. XLIX, fig. 4). The variation in shape, margin, etc., is well shown in the figures quoted and in the examples here figured.

It is with much hesitation that I venture to found this species; not, indeed, from lack of sufficient material, but rather from embarrassment of riches. Lesquereux, through whose hands much of this material has passed, would separate them not only into many species

but into several genera (Quercus, Alnus, Betula, Carpinus, etc.), while Newberry, judging from what he actually did, would combine them all under his *Populus polymorpha*. I can not believe that they belong to Populus. The only living species with which it is reasonable to compare them is *Populus alba*, which has, it is true, very variable leaves, but they seem of a different type and generically unlike the ones under consideration. I have, therefore, broken up Newberry's *Populus polymorpha*, placing certain of them under this form. If Newberry's elastic species was maintained it would be polymorphous enough to include them all, but I do not think it will adequately represent the facts to do so.

In regard to Lesquereux's point of view, it may be said that if extreme examples were selected it might seem logical to call them species, but when the whole are grouped together it is found absolutely impossible to draw any satisfactory line between them. Take, for example, the question of shape. The narrowest possible form may be unlike the broadest form, yet every step between them can be found. So, also, from the specimens with a wedge-shaped base to those with a a truncate base, and still farther to those with a markedly inæquilateral base, there are gradual steps. In the matter of nervation, however, there are only comparativelyslight differences, yet even here the variations are all connected.

The form most nearly related to this is *B. heterodonta* Newb., from which it is sometimes almost impossible to separate it. In general, the latter species has much larger leaves, with coarser toothed margins and a more markedly inaequilateral base. Yet these differences come so near breaking down that it is sometimes difficult to say where a particular specimen shall go.

Locality.—Bridge Creek, Oregon. Found abundantly in all collections (U. S. Nat. Mus., Nos. 8481, 8482).

BETULA HETERODONTA Newb.

BETULA HETERODONTA Newb., Proc. U. S. Nat. Mus., Vol. V, p. 508, 1883; Later Extinct Floras, p. 64, Pl. XLVI, figs. 1–4; Pl. XLV, figs. 1, 6, 1898.

As stated under the preceding species, it is almost impossible to distinguish certain of the forms of this species from that.

Locality.—Bridge Creek, Oregon. Collected by Rev. Thomas Condon (U. S. Nat. Mus., No. 7071) and Maj. Charles E. Bendire (U. S. Nat. Mus., No. 8483).

BETULA BENDIREI n. sp.

Pl. IV, fig. 2.

Leaf membranaceous in texture, nearly circular in outline, abruptly rounded below to a nearly truncate base, rounded similarly above to

a very short obtusely acuminate apex; margin rather coarsely toothed, most of the teeth, but especially those on the lower half of the blade, with several smaller teeth; midrib rather thick, straight; secondaries about 9 pairs, opposite below, becoming subopposite above, the two lower pairs emerging at an angle of about 20°, others about 45°, all craspedodrome and ending in the large teeth, often with one or two branches on the lower side, which pass to smaller teeth; nervilles thin, mainly percurrent and oblique to the secondaries; finer nervation producing a minute network.

I have ventured to describe this species on the single example figured. It is a little more than 4.5 cm. in length and is 4 cm. in width. As may be seen, it is a very perfect and symmetrical leaf, nearly circular in outline, with rather coarsely, doubly dentate margins.

Among living forms this is perhaps closest to *Betula occidentalis* Hooker, which is now found in the same general region. It has the same shape and nervation, but differs slightly in the marginal dentation. It is also quite similar, except as regards the margin, to certain forms of *B. papyrifera* Marshall.

Among fossil forms it has a number of evident affinities. From *B. heteromorpha* it differs in being nearly circular in shape, with an equal base and regularly spaced secondaries.

Locality.—Bridge Creek, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 8485).

BETULA ANGUSTIFOLIA Newb.

BETULA ANGUSTIFOLIA Newb., Proc. U. S. Nat. Mus., Vol. V, p. 508; Later Extinct Floras, p. 63, Pl. XLVI, fig. 5; Pl. XLVII, fig. 5, 1898.

A large number of leaves of this species are present in every collection from this locality.

Locality.—Bridge Creek, Oregon. Collected by Rev. Thomas Condon (Types, U. S. Nat. Mus., Nos. 7074, 7075).

BETULA? DAYANA, n. sp.

Pl. IV, fig. 4.

Leaf small, membranaceous, ovate-cordate, obtuse at apex; margin very coarsely toothed; midrib thin; secondaries thin and obscure, about four pairs, alternate, ending in the larger teeth; finer nervation producing a very fine network.

A single leaf only. The length is 2 cm. and the width 1.5 cm.

Locality.—Mascall beds, Van Horn's ranch, Oregon, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., No. 8535).

ALNUS CARPINOIDES Lesq.

ALNUS CARPINOIDES Lesq., Cret. and Tert. Fl., p. 243, Pl. L, fig. 11; Pl. LI, figs. 4, 4[a], 5, 1883.

All collections from Bridge Creek contain a large number of leaves of this species, which has been well described and figured by Lesquereux.

Locality.—Bridge Creek (types in Mus. Univ. Cal., No. 1759, figs. 4, 4[a]; 1764, fig. 5). One and one-half miles east of Clarnos Ferry. Collected by Merriam's expedition of 1900 (Mus. Univ. Cal., Nos. 931.) One-half mile northeast of Fossil. Collected by Merriam's expedition of 1900 (Mus. Univ. Cal., Nos. 923, 928).

ALNUS SERRULATA FOSSILIS Newb.

ALNUS SERRULATA FOSSILIS Newb., Later Extinct Floras, p. 66, Pl. XLVI, fig. 6, 1898.

The example figured by Newberry as the type is the only one that has thus far been found, with the exception of a single somewhat doubtful example obtained by the University of California.

Locality.—Bridge Creek, Grant County, Oregon. Collected by Rev. Thomas Condon (U. S. Nat. Mus., No. 7091).

ALNUS MACRODONTA, n. sp.

Pl. IV, fig. 1.

Leaf of firm texture, ovate-cordate in shape, abruptly rounded below to a heart-shaped base and narrowed above to an apparently obtusely acuminate apex; margin coarsely and irregularly dentate, the teeth all obtuse; midrib thick, especially in the lower half of the blade; secondaries about 9 pairs, the two lower pairs sub-opposite and at a right angle, other secondaries at varying angles and distances, all more or less curving upward, craspedodrome and often with several branches in the lower side, which pass to marginal teeth; nervilles numerous and prominent, usually percurrent and rather oblique to the secondaries; finer nervation producing a copious, irregularly quadrangular network.

This species is based on the single example figured. It lacks, as may be seen, a considerable portion of one side and all of the apex. It is broadly ovate, with abruptly truncate, heart-shaped base and coarsely dentate margin. The length was about 7 cm. and the width about 5.5 cm.

Locality.—Bridge Creek, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 8551).

ALNUS sp?, fruit of, Newb.

ALNUS sp?, fruit of, Newb., Later Extinct Floras, p. 67, Pl. XLVI, fig. 7, 1898.

Locality.—Bridge Creek, Grant County, Oregon. Collected by Rev. Thomas Condon (U. S. Nat. Mus., No. 7093).

ALNUS KEFERSTEINII? (Göpp.) Unger.

ALNUS KEFERSTEINII (Göpp.) Unger. Lesquereux, Proc. U. S. Nat. Mus., Vol. XI, p. 18, 1888.

A single example having no portion of the margin preserved. It is referred with hesitation to this species.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2419).

Family FAGACEÆ.

FAGUS? sp.

FAGUS CASTANEÆFOLIA Unger. Lesquereux, Proc. U. S. Nat. Mus., Vol. XI, p. 18, 1888.

This determination was based on a single fragment of the lower portion of a leaf. It is doubtful even whether it belongs to Fagus, and can have no value in fixing the age of or affording a stratigraphic mark for these beds.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2466).

QUERCUS FURCINERVIS AMERICANA Knowlton.

QUERCUS FURCINERVIS AMERICANA Knowlton, Cat. Cret. and Tert. Pl. N. A., p. 192, 1898.

Quercus furcinervis (Rossm.) Ung. Lesquereux, Proc. U. S. Nat. Mus., Vol. XI, p. 22, 1888.

This is not the European form, and is best indicated by the varietal name given above. This determination is based solely on a part of the middle portion of a single leaf, which is very similar indeed to *Castanea pulchella* Knowlton[a] from Lower Miocene beds in the Yellowstone National Park.

Locality.—Cherry Creek, Crook County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2554).

QUERCUS? sp.

Pl. VIII, fig. 4.

Leaf very thick, narrowly obovate, obtusely wedge-shaped at base (apex destroyed); margin entire below, probably toothed above; midrib very thick, especially below, secondaries also strong, 6 or 7 pairs, alternate at an angle of about 45°, a pair near the middle of the blade largest, with strong outside branches, probably ending in lobes or teeth; nervilles very strong and deeply impressed, both broken and percurrent; finer venation producing large areas.

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[a] Mon U. S Geol. Survey, Vol. XXXII, Pt. II, p. 702, Pl. LXXXVII, fig. 1.

A single broken specimen is all that I now refer to this form. It was clearly a large thick leaf, with prominent deeply impressed nervation. It is entire in the lower portion, but from the size and disposition of the secondaries in the middle of the blade it was apparently lobed or toothed above. Its length was about 12 cm. and the width about 6.5 cm. It is doubtfully referred to Quercus.

Locality.—Cherry Creek, Crook County, Oregon. Collected by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., No. 8555).

QUERCUS PAUCIDENTATA Newb.

QUERCUS PAUCIDENTATA Newb., Proc. U. S. Nat. Mus., Vol. V, p. 505, 1883; Later Extinct Floras, p. 76, Pl. XLIII, fig. 1, 1898.

It is with some misgiving that this species is permitted to stand. It is based, as Newberry says, on a single example, the only one ever found. It is in all probability a large leaf of *Q. affinis*, but rather than complicate matters by combining forms without sufficient material I have preferred to keep it distinct.

Locality.—Bridge Creek, Grant County, Oregon. Collected by Rev. Thomas Condon (U. S. Nat. Mus., No. 7059).

QUERCUS DRYMEJA Unger.

QUERCUS DRYMEJA Unger. Lesquereux, Cret. and Tert. Fl., p. 245. Pl. LIV, fig. 4, 1883.

Lesquereux has figured a single leaf of this form, and the Bendire collection contains another example. Neither of these is perfectly preserved, but they seem to differ from other allied forms. It may be, however, that they are very large leaves of *Q. consimilis* Newb.

Locality.—Bridge Creek, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., Nos. 9231, 9328).

QUERCUS SIMPLEX Newb.

QUERCUS SIMPLEX Newb., Proc. U. S. Nat. Mus., Vol. V., p. 505, 1883; Later Extinct Floras, p. 78, Pl. XLIII, fig. 6, 1898.

As stated by Newberry the collections from Bridge Creek always contain a large number of leaves of this species. They are of the same size and shape as leaves of *Q. consimilis*, and only differ in being entire margined, and Newberry questioned as to whether they might not be only a varietal form of that species. As none of the specimens that have passed under my observation show any such gradation, it may be taken as established that they are distinct.

Locality.—Bridge Creek, Grant County, Oregon, collected by Rev. Thomas Condon (U. S. Nat. Mus., No. 7058a) and Maj. Charles E. Bendire (U. S. Nat. Mus., Nos. 9219, 9227, 9238, 9249, 9252, 9264, 9283, 9289, 9295, 9300, 9302, 9312, 9316, 9332, 9336, 9369, 9380, 9383). Officer's ranch, lower end of Butler Basin. Collected by Dr. John C. Merriam, July 22, 1901 (U. S. Nat. Mus., No. 9210).

QUERCUS AFFINIS (Newb.) n. comb.

Fraxinus affinis Newb., Proc. U. S. Nat. Mus., Vol. V, p. 510, 1883; Later Extinct Floras, p. 127, Vol. XLIX, fig. 5, 1898 (1899).

Quercus furcinervis Rossm. Lesquereux, Cret. and Tert. Fl., p. 244, Pl. LIII, figs. 10–12, 1883.

Quercus Breweri Lesq., idem, p. 246, Pl. LIV, fig. 9 (not other figures described as *Q. Breweri*) 1883.

This species came first into the hands of Dr. Newberry and was called by him *Fraxinus affinis*. He appears to have noticed only a single example, namely, the one made the type, yet there is a larger leaf on the same piece of matrix. A little later a number of similar leaves from the same locality were studied by Lesquereux and by him identified with *Quercus furcinervis* of Rossmassler, and his own *Q. Breweri* (See synonymy above).

As Newberry well states, there is a strong resemblance between his leaf and the living *Fraxinus americana*, yet in placing it by the side of the figures given by Lesquereux there can be no doubt that only one species is represented, and moreover that this is much more like Quercus than Fraxinus. This view is further strengthened by the finding of additional leaves in later collections. It is therefore clear to my mind that they are oak leaves, and I have placed them under Quercus.

It now remains to explain the selection of the specific name for these leaves. Newberry's *Fraxinus affinis* was published March 21, 1883, whereas Lesquereux's volume, as pointed out on page 12, could not have been issued until late in 1883 or more probably not until sometime in 1884. Newberry, therefore, clearly has priority. Now, if either of Lesquereux's references of these leaves to species of Quercus was valid, it would simply be necessary to transfer *Fraxinus affinis* to the one selected, but in my opinion they are not. I do not think that the leaves referred to *Quercus furcinervis*[a] are the same as Rossmassler's species, and, obviously, the leaf called *Quercus Breweri*[b] is not the same as the others with which it is associated, and is identical with the one on the preceding plate. On these grounds I have retained Newberry's specific name because it is the oldest, and I have placed them under Quercus because I consider them to be oak leaves.

Locality.—Bridge Creek, Grant County, Oregon. Collected by Rev. Thomas Condon (U. S. Nat. Mus. No. 7125). Type of fig. 9, op. cit., is in Mus. Univ. Cal., No. 1774.

QUERCUS CONSIMILIS Newb.

QUERCUS CONSIMILIS Newb., Proc. U. S. Nat. Mus., Vol. V, p. 505, 1883; Later Extinct Floras, p. 71, Pl. XLIII, figs. 2–5, 7–10, 1898.

This species is very abundant in the collections from Bridge Creek, and is well characterized and figured by Newberry. It is closely allied

[a] Lesquereux, Cret and Tert. Fl., Pl. LIII, figs. 10–12.
[b] Idem, Pl. LIV, fig. 9.

to *Q. Breweri* Lesq., but can be readily distinguished by being shorter and relatively much broader.

A single broken leaf was found by Merriam at Officer's ranch, in the lower end of Butler Basin.

Locality.—Bridge Creek, Grant County, Oregon. Collected by Rev. Thomas Condon (U. S. Nat. Mus., Nos. 7048, 7050, 7057, 7063, 7070) and Maj. Charles E. Bendire (U. S. Nat. Mus., Nos. 9230, 9235, 9239, 9247, 9251, 9259, 9261, 9271, 9276, 9280, 9282, 9287, 9305, 9311, 9321, 9329, 9333, 9337, 9342, 9344, 9347, 9351, 9362). Officer's ranch, lower end of Butler Basin. Collected by Merriam, July 22, 1901 (U. S. Nat. Mus., No. 9209).

QUERCUS BREWERI Lesq.

QUERCUS BREWERI Lesq., Cret. and Tert. Fl., p. 246, Pl. LIV, figs. 5–8 (non fig. 9), 1883.

Some years ago, when preparing the manuscript for my Catalogue of the Cretaceous and Tertiary Plants of North America, I was led from a casual examination of the figures to refer this species to *Q. consimilis* Newb. and *Q. paucidentata* Newb. Since that time I have found the long narrow leaves of *Q. Breweri* in the vicinity of Ashland, Oregon, and I have also gone carefully over the abundant material from Bridge Creek, which contains a number of finely preserved leaves, and I am now inclined to regard them as distinct from *Q. consimilis*. They are undoubtedly close to this species, yet differ in being much longer and narrower. They can be readily distinguished. I have seen and examined the types of this species in the University of California, and I am the more convinced that it is distinct.

Locality.—Bridge Creek, Grant County, Oregon. Collected by Rev. Thomas Condon (U. S. Nat. Mus., No. 9345), by Maj. Charles E. Bendire (U. S. Nat. Mus., Nos. 9218, 9224, 9277, 9294, 9322, 9331, 9345, 9352), and by F. H. Knowlton. Types in Mus. Univ. Cal., Nos. 1761, 1762, 1763.

QUERCUS PSEUDO-ALNUS Ettingshausen.

QUERCUS PSEUDO-ALNUS Ettingshausen. Lesquereux, Cret. and Tert. Fl., p. 244, Pl. LIII, figs. 1–7, 1883.

Populus polymorpha Newb., in part. Later Extinct Floras, p. 50, Pl. XLIX, fig. 7, 1898.

Under the above name Lesquereux has figured a number of leaves from Bridge Creek. They differ considerably among themselves, yet may well belong to a single polymorphous species. Nearly all the forms are abundant in any collection from this locality.

The leaf figured by Newberry as *Populus polymorpha* (loc. cit., fig. 4) is certainly the same as fig. 6 of Pl. LIII in the Cretaceous and Tertiary Flora, and I have placed it under this species as determined by Lesquereux. It is one of the most abundant forms in all collections.

Locality.—Bridge Creek, Oregon. Collected by Rev. Thomas Condon (U. S. Nat. Mus., No. 7051) and Maj. Charles E. Bendire (U. S. Nat. Mus., Nos. 9229, 9250, 9253, 9266, 9274, 9292, 9307, 9309, 9317, 9319, 9326, 9334, 9343, 9355, 9358, 9365, 9368, 9372, 9374). Types of original American figured specimens in Mus. Univ. Cal., fig. 1, No. 1767; fig. 2, No. 1768; fig. 3, No. 1769; fig. 4, No. 1770; fig. 5, No. 1771; fig. 6, No. 1772; fig. 7, No. 1773. Officer's ranch, lower end of Butler Basin. Collected by Dr. John C. Merriam, July 22, 1901 (U. S. Nat. Mus., No. 9204).

QUERCUS OREGONIANA, n. sp.

Pl. VI, figs. 2, 3; Pl. VII, fig. 1.

QUERCUS, n. sp., Knowlton in Merriam, Univ. Cal., Bull. Dept. Geol., Vol. II, No. 9, p. 288, 1901.

Populus polymorpha Newb., in part. Proc. U. S. Nat. Mus., Vol. V, p. 506; Later Extinct Floras, p. 50, Pl. XLVI, fig. 4 (not the other figures of *P. polymorpha*).

Leaf membranaceous in texture, elliptical-ovate or slightly elliptical-obovate in shape, rather abruptly rounded at base, obtusely acuminate at apex; margin coarsely and irregularly toothed, the teeth rounded or somewhat acute (petiole not preserved); midrib rather slender, perfectly straight; secondaries 8 or 9 pairs, alternate, arising at an angle of 45° or 50°, nearly straight, ending in the larger marginal teeth, often with one or two branches on the lower side, which also pass to the marginal teeth; the secondaries in the lower part of the blade closer than those above and at a less angle; nervilles numerous, percurrent or broken, approximately at right angles to the secondaries; finer nervation producing a close, irregularly quadrangular network.

This species is based on two examples, one of which (Pl. VI, fig. 2) is the original of one of Newberry's types of *Populus polymorpha*, and the other (Pl. VII, fig. 1) a smaller specimen that was identified by Lesquereux as *Carpinus betuloides* Unger. The leaves are about 6 cm. in length and 4 cm. in width. The first-mentioned example is nearly perfect, lacking only the petiole, while the other lacks all of the basal portion. The drawing given in Newberry's Later Extinct Floras is not quite correct as regards the form, the teeth being uniformly rounded, and the nervation is only partially shown. The other example has never before been figured.

I am moved to take this leaf from Newberry's polymorphic aggregation for two reasons: First, because it differs from the other forms included under *P. polymorpha;* and, second, because I can not believe that it belongs with the genus Populus. It has much more the appearance and general facies of a Quercus, and for these reasons has been removed.

Locality.—Bridge Creek, Oregon. Collected by Rev. Thomas Condon (U. S. Nat. Mus., No. 7049) and Maj. Charles E. Bendire (U. S. Nat. Mus., No. 8484).

QUERCUS PSEUDO-LYRATA Lesq.

QUERCUS PSEUDO-LYRATA Lesq., Foss. Pl. Aurif. Gravel, p. 8, Pl. II, figs. 1, 2, 1878; Proc. U. S. Nat. Mus. Vol. XI, p. 17, Pl. X, fig. 1, 1888; Knowlton, Univ. Cal., Bull. Dept. Geol., Vol. II, No. 9, p. 308, 1901.

Quercus pseudo-lyrata acutiloba Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 17, Pl. XI, fig. 1, 1878.

Quercus pseudo-lyrata brevifolia Lesq., idem, p. 18, Pl. X, fig. 2.

Quercus pseudo-lyrata latifolia Lesq., idem, p. 18, Pl. XII, fig. 1.

Quercus pseudo-lyrata obtusiloba Lesq., idem, p. 18, Pl. X, fig. 3.

This species was originally described and figured by Lesquereux in his Fossil Plants of the Auriferous Gravel (p. 8, Pl. II, figs. 1, 2). After the description he has the following to say regarding the locality:

> The locality is unknown, or at least not marked in the catalogue of the labels. The matrix of the specimens is a white, soft clay like that of the Chalk Bluffs of Nevada County, California, and no other species is preserved upon them except a fragment of a leaf apparently referable to *Castanea intermedia* Lesq. These specimens are evidently from the same formation and age as those of the Chalk Bluffs.

Both of the type specimens on which Lesquereux based his description and the above statement are preserved in the Paleontological Collection of the University of California (Nos. 1796 and 1796a), where I recently had the opportunity of examining them. A glance at the matrix was sufficient to show that they came from Van Horn's ranch, John Day Valley, Oregon. They form a part of the original Voy collection, made about thirty years ago, which fact is recorded on the back of each speciman. The matrix, mistaken by Lesquereux for a white, soft clay, is made up of very fine spicules of glass of volcanic origin, and is unmistakably that of the Van Horn's ranch locality. From this it appears that *Quercus pseudo-lyrata* was not originally, and, so far as now known, has never been found in California, or indeed outside of the John Day Basin. These facts are of great importance, since this characteristic species was relied upon to establish the correlation between the Auriferous gravels and the Van Horn's ranch deposits.

I have before me all of the type and duplicate material, belonging to the United States National Museum, on which Lesquereux based the above enumerated varieties of this species, as well as the material obtained by Dr. John C. Merriam in 1900 for the University of California, and by myself in 1901. This comprises fully one hundred more or less perfect examples. There are, it is true, slight differences between the various forms, but I am now quite convinced that they are only individual variations, such as may be noted in the leaves of many species of living oaks. I have placed all these leaves in a single series and have found it quite impossible to draw any satisfactory line between them. They have consequently been referred to the single original form.

Locality.—Van Horn's ranch and vicinity, on South Fork of John Day River, 12 miles west of Mount Vernon, Grant County, Oregon. Collected originally by C. D. Voy (Univ. Cal., Nos. 1796, 1796a). Since collected by Maj. Charles E. Bendire (U. S. Nat. Mus., Nos. 2565, 2566, 2568, 2569, 2570), Dr. John C. Merriam in 1900 (Mus. Univ. Cal., Nos. 838, 839, 841, 842, 843, 844, 847a, 849, 852, 859, 865, 872), and by F. H. Knowlton, in July, 1901 (U. S. Nat. Mus., Nos. 8999–9015).

QUERCUS MERRIAMI n. sp.

Pl. VI, figs. 6, 7; Pl. VII, figs. 4, 5.

QUERCUS n. sp., Knowlton in Merriam, Univ. Cal., Bull. Dept. Geol., Vol. II, No. 9, p. 308, 1901.

Quercus pseudo-lyrata angustiloba Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 17, Pl. XI, fig. 2, 1888.

Leaves coriaceous in texture, narrowly lanceolate in outline, wedge-shaped at base, slenderly acuminate at apex; provided with 4 or 5 pairs of alternate or subopposite lobes, which are deltoid or deltoid-lanceolate in shape, usually sharp-pointed, but occasionally with the basal ones obtuse and rounded; petiole very long and slender; midrib moderately strong; secondaries usually at an acute angle, as many as the lobes and ending in their apices; intermediate secondaries few, apparently craspedodrome; finer nervation not well retained.

This species is now represented by more than twenty-five more or less perfect examples. The one shown in Pl. VII, fig. 4, was figured by Lesquereux under the name of *Quercus pseudo-lyrata angustiloba.*[a] As shown in Lesquereux's figure, it appears to lack the basal portion with the petiole, but this was covered by matrix, which has now been removed, exposing the long, slender petiole. The other specimens figured, as well as all but one or two of those now known, were obtained in 1901.

The first-mentioned example (Pl. VI, fig. 6) is about 14 cm. long, including the petiole, which is fully 4 cm. long. At the widest point between the lobes it is only a little over 3 cm., while at the narrowest point, which is near the middle of the blade, it is considerably less than 1 cm. The still larger example, shown in fig. 6, must have been 15 or 16 cm. long and 6 cm. broad between the points of the lobes. At the narrowest point it is about 2 cm. One of the smallest leaves is shown in Pl. VI, fig. 6. It is 9.5 cm. long, including the petiole of about 1.5 cm. in length. The broadest portion between the lobes is 2 cm., and the narrowest only 7 mm. in width.

The specimens representing this species are intimately associated with the numerous leaves of typical *Q. pseudo-lyrata*, and it is hardly

[a] This varietal name can not be retained, as it is preoccupied by *Quercus angustiloba* Al. Br., in Ludgw. Palæontogr., Vol. VIII, p. 103, Pl. XXXVI, fig. 3, 1861.

to be wondered that Lesquereux, with only a single example before him, should regard it as an extremely narrow form of that species. But with the fine series now at hand it is clear that it is very distinct.

Among living species this form is certainly suggestive of *Quercus heterophylla* Michx. f., the so-called Bartram oak, which is supposed to be a hybrid between *Q. phellos* and *Q. rubra*. This resemblance may be only superficial, but it is nevertheless plain.

I take pleasure in naming this species in honor of Dr. John C. Merriam, of the Univerity of California.

Locality.—Van Horn's ranch and the two other near-by localities, 12 miles west of Mount Vernon, Grant County, Oregon. Type of fig. 4 collected by Major Bendire (U. S. Nat. Mus., No. 8505). Types of other figures collected by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., Nos. 8506, 8507). Type of fig. 7 collected by Merriam's expedition of 1900 (Mus. Univ. Cal., No. 846).

QUERCUS DURIUSCULA n. sp.

Pl. VIII, fig. 2.

Leaf coriaceous in texture, broadly obovate in general outline, deeply lyrate-pinnatifid into about five lobes, of which the basal are very small, triangular, and obtuse, the other broad, rounded, with deeply undulate or toothed lobes; midrib strong; secondaries three pairs, alternate, ending in the principal lobes, the upper ones with strong branches passing to the smaller lobes; finer nervation not well retained.

Unfortunately only one example of this form was found, and even this lacks a small portion of the base and has the upper lobes somewhat injured, evidently before fossilization. The length was about 5.5 cm. and the greatest width about 5 cm. The two basal lobes are less than 1 cm. in length. The outline and such details of nervation as are preserved are well shown in the figure.

This leaf clearly belongs to the white-oak group, and apparently finds its greatest affinity with *Quercus minor* (Marsh.) Sargent, the well-known post, or iron, oak, a species now common over much of the region east of the Rocky Mountains south of Massachusetts. It is so close to this species, in fact, that it can hardly be distinguished from many of the smaller leaves. It would therefore seem beyond question that the living *Q. minor* is a direct descendant of this fossil form, if, indeed, it has not remained practically unchanged from the time the Mascall beds were laid down to the present day.

Locality.—White hill one-half mile east of original Van Horn's ranch locality, 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., No. 8508).

QUERCUS URSINA n. sp.

Pl. VII, figs. 2, 3.

QUERCUS n. sp., Knowlton in Merriam, Univ. Cal., Bull. Dept. Geol., Vol. II, No. 9, p. 308, 1901.

Leaves coriaceous in texture, roughly obovate in general outline, 5 to 7 lobed, the lobes triangular or triangular-ovate in shape, very acute and apparently bristle-tipped; petiole long, relatively strong; nervation consisting of a strong midrib and as many alternate, rather thin secondaries as there are lobes; finer nervation not fully preserved.

This species is represented by several very well-preserved leaves. They are small leaves, about 4.5 cm. long, exclusive of the petiole, and about 4.5 cm. broad. The petiole is fully 1.5 cm. in length. The lobes, usually about 6 in number, are mainly triangular in shape, and are entire or occasionally with a single small sharp tooth, as shown in Pl. VII, fig. 2.

This species, so far as I am able to determine, finds its closest affinity among living species with *Quercus nana* (Marsh.) Sargent, the bear or scrub oak of the Eastern United States. The fossil form has a longer petiole, but otherwise the shape is very similar to certain of the smaller leaves of this species.

It is barely possible that these leaves may be only small forms of the polymorphous *Quercus pseudo-lyrata*, but I do not at present think so, for out of more than a hundred examples of the latter species there are no forms that can well be regarded as intermediate.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Merriam's expedition of 1900 (type of fig. 2, in Mus. Univ. Cal., No. 841). White hill one-half mile east of above-mentioned locality. Collected by Knowlton and Merriam, July, 1901 (type of fig. 3, U. S. Nat. Mus., No. 8509).

QUERCUS DAYANA n. sp.

Pl. VI, fig. 1.

Leaf coriaceous, broadly elliptical-lanceolate, about equally obtusely acuminate at both base and apex; margin undulate, perhaps reflexed, otherwise entire; petiole very short and thick; midrib also very thick; secondaries thin and obscure, apparently about 12 pairs, alternate, emerging at a low angle, apparently ending in or very near the margin; finer nervation not retained.

The leaf figured—the only one thus far found—is 3.5 cm. long and 9 mm. broad and has the petiole only 3 mm. long. The outline and scant nervation are well shown in the figure.

This little leaf has such a familiar appearance that it would seem to be a known species, and, indeed, it does resemble more or less closely

a number of forms, but after careful comparison I am forced to regard it as hitherto undescribed. It is clearly an oak leaf of the well known *sempervirens* type, and is allied to a number of fossil forms of this kind. It differs, for instance, from *Quercus simplex* Newb.,[a] in being much shorter, relatively broader, with shorter petiole and closer, lower angled secondaries. It somewhat resembles *Q. convexa* Lesq.,[b] of the Auriferous gravels of California, but differs in nervation, petiole, and other details. It is not greatly unlike the smallest leaves of *Q. simulata* Knowlton,[c] from the Payette formation of Idaho, but is sharper at both ends and has an undulate margin and a much shorter, thicker petiole.

Locality.—White hill one-half mile east of original Van Horn's ranch locality. Collected by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., No. 8546).

QUERCUS HORNIANA Lesq.

Pl. VIII, fig. 1.

QUERCUS HORNIANA Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 17, 1888 (the figure given on Pl. V, fig. 6, is not a figure of this specimen, being a figure of a specimen of *Ulmus californica*).

Castanea atavia Unger. Lesquereux, Cret. and Tert. Fl., p. 247, Pl. LII, fig. 2, 1884.

The type specimen of Lesquereux's *Quercus horniana* has not previously been figured, the figure supposed to represent it being that of a specimen of *Ulmus californica* from the same beds. It is here figured for the first time, and it needs but a glance to show that it is identical with the leaf identified by Lesquereux as *Castanea atavia* Unger, a fact apparently overlooked by Lesquereux when he established *Q. horniana*. I have not been able to see any European material of *Castanea atavia*, but a study of the type figures,[d] as well as others, leads me to the conclusion that Lesquereux was in error in identifying the John Day leaf with this species. In the European species the teeth are smaller and lower, the secondaries opposite and only about ten pairs instead of fifteen or more pairs, and the finer nervation is much more open. In the John Day form the margin is entire for a considerable distance above the base while the upper portion is provided with very large, sharp teeth.

While there can be no doubt that this leaf is the same as that figured by Lesquereux as *Castanea atavia*, there may be some as to its being referred to Quercus. The size and shape of the leaf, however, are very suggestive of an oak, and for the present it may remain in this genus. It is very well marked and one not likely to be easily mistaken for anything thus far discovered in these beds.

[a] Later Extinct Floras, p. 78, Pl. XLIII, fig. 6.
[b] Foss. Pl. Aurif. Gravel, p. 4, Pl. I, figs. 13-17, 1878.
[c] Eighteenth Ann. Rept. U. S. Geol. Surv., Pt. III, p. 728, Pl. CI, fig. 3.
[d] Foss. Fl. v. Sotzka, p. 34 (164), Pl. X (XXXI), figs. 5-7, 1850.

Locality.—Van Horn's ranch, South Fork of John Day River, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 8504).

QUERCUS? sp. Knowlton.

Pl. VIII, fig. 3.

QUERCUS? sp., Knowlton in Merriam, Univ. Cal., Bull. Dept. Geol., Vol. II, No. 9, p. 308, 1901.

The collection made by the University of California contains a single leaf—the one figured—which appears to belong to Quercus. Only the basal portion is preserved together with a very short, thick petiole. The texture seems to have been coriaceous; the shape is lanceolate, wedge-shaped at base, and entire margined. The midrib is very thick and the secondaries—several pairs—subopposite. None of the finer nervation is retained.

This may possibly be a fragment of *Quercus simplex* Newb., which is so abundant at Bridge Creek, but it is only a fragment and the nervation is not well preserved, so I have hesitated to so regard it.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Merriam's expedition of 1900. (Mus. Univ. Cal., No. 860.)

Family ULMACEÆ.

ULMUS SPECIOSA Newb.

ULMUS SPECIOSA Newb., Proc. U. S. Nat. Mus., Vol. V, p. 507, 1883; Later Extinct Floras, p. 80, Pl. XLV, figs. 2–4, 7 (non figs. 5 and 8), 1898.
Ulmus pseudo-americana Lesq., Cret. and Tert. Fl., p. 249, Pl. LIV, fig. 10, 1883.

The leaf made the type of Lesquereux's *Ulmus pseudo-americana* is preserved in the paleontological collection of the University of California (No. 1758), and as it is clearly the same as the large leaves figured as the types of Newberry's *U. speciosa* and is referred to it, as the latter has priority.

As Newberry states, the collections from Bridge Creek contain a number of elm leaves of the character and size shown in fig. 8 of his plate; that is, they are very much smaller and have less coarsely cut margins than those shown in figs. 2–4, and 7. He decides, however, that these differences are not sufficient to warrant separating them as a distinct species. If these extremes of size and shape were connected by intermediate forms it would be unwarranted to separate them, but among a considerable number this is not found to be the case. It is possible to determine from even a relatively small fragment the form in hand. It therefore seems justifiable to separate them, and I have accordingly done so, retaining the name *speciosa* for the larger leaves and giving to the smaller ones the name of *Ulmus Newberryi*.

Ulmus speciosa, as here emended, may be described as follows: Leaves 10 to 13 cm. in length, 5.5 to 6 cm. in width, petioled, long ovoid or elliptical in outline, very unequal sided at base, narrow pointed at apex; margins coarsely and doubly serrate; nervation strong, very regular, with a strong midrib and some 15 to 20 pairs of thin, close, parallel secondaries; nervilles numerous, close, mainly percurrent and at right angles to the secondaries.

The fruit probably of this species is figured and described by Newberry.

Locality.—Bridge Creek, Grant County, Oregon. Collected by Rev. Thomas Condon (U. S. Nat. Mus., Nos. 7065, 7066, 7067, 7068) and Maj. Charles E. Bendire (U. S. Nat. Mus., Nos. 9217, 9367).

ULMUS NEWBERRYI n. sp.

Pl. IX, fig. 4.

ULMUS n. sp., Knowlton in Merriam, Univ. Cal., Bull. Dept. Geol., Vol. II, No. 9, p. 288, 1901.

Ulmus speciosa Newb., Later Extinct Floras, p. 80, Pl. XLV, figs. 5 and 8 (now figs. 2–4 and 7), 1898 (1899).

Leaves membranaceous in texture, lanceolate in outline, narrowed, and very unequal sided at base, long and slender pointed at apex; margin coarsely and irregularly doubly serrate, the primary teeth large, of quite regular size, the other teeth smaller and quite irregular; midrib rather thin, perfectly straight; secondaries about 12 or 15 pairs, parallel, at an acute angle and ending in the larger teeth; nervilles numerous, fine, mainly broken, producing a large block network between the secondaries.

This species is founded on a considerable number of leaves besides the ones figured by Newberry under *U. speciosa*. One of the most perfect has been figured here. This is very narrowly lanceolate, 10 cm. in length and only a little over 3 cm. in width. The petiole is about 5 mm. long. Other examples are only about 6 cm. long and 2.5 cm. wide, and this is the usual size.

As pointed out under *U. speciosa*, this species may be distinguished by its much smaller size, much narrower shape, and more oblique base. In fact, it approaches closer to *U. californica*[a] in size and shape than to *U. speciosa*. It differs from *U. californica* in having larger, doubly dentate teeth, those of the former species being small and only simply dentate.

Locality.—Bridge Creek, Grant County, Oregon. Collected by Rev. Thomas Condon (U. S. Nat. Mus., No. 7064) and Maj. Charles E. Bendire (U. S. Nat. Mus., No. 8493).

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[a] Mem. Mus. Comp. Zool., Vol. VI, No. 2, p. 15, Pl. IV, fig. 2, 1878.

ULMUS PLURINERVIA Unger.

ULMUS PLURINERVIA Unger. Lesquereux, Proc. U. S. Nat. Mus., Vol. XI, p. 18, 1888.

A single specimen with its counterpart is all that has been found of this form. It is a little larger than the figure given by Heer[a] of the Alaskan form, but is otherwise the same.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2620).

ULMUS CALIFORNICA? Lesq.

ULMUS CALIFORNICA Lesq., Foss. Pl. Aurif. Gravel, p. 15, Pl. IV, fig. 2, 1878; Proc. U. S. Nat. Mus., Vol. XI, p. 18, Pl. V. fig. 6 (there wrongly stated to be a figure of *Quercus horniana*), 1888.

The collections contain several examples, one of which was referred by Lesquereux to his *Ulmus californica.* The others are similar to this and should properly go with it. The question as to whether they are properly referred to this species is a rather difficult one to settle. None of the leaves are nearly perfect nor do they agree in all particulars with the types. The secondaries incline to arch slightly outward instead of strongly upward. The character of the teeth can not be made out satisfactorily. In view of these statements, it seems best to question their reference to this species, and await future material to settle the matter definitely.

Locality.—Mascall beds, Van Horn's ranch, 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2621) and by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., Nos. 8983–8985).

PLANERA UNGERI Ettingshausen.

PLANERA UNGERI Ettingshausen. Lesquereux, Proc. U. S. Nat. Mus., Vol. XI, p. 19, 1888.

This species is represented by a single example and its counterpart, and although not perfectly preserved may well belong to this form.

Locality.—Mascall beds, Van Horn's ranch, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2534.)

Family MORACEÆ.

FICUS TENUINERVIS Lesq.

FICUS TENUINERVIS Lesq., Cret. and Tert. Fl., p. 164, Pl. XLIV, fig. 4, 1883; Proc. U. S. Nat. Mus., Vol. XI, p. 23, 1888.

The single broken leaf upon which Lesquereux based its presence at Cherry Creek remains unique. It is described and discussed at length in the paper above quoted.

Locality.—Cherry Creek, Crook County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2479).

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[a] Fl. Foss. Alaska, p. 34, Pl. V, fig. 1, 1869.

FICUS PLANICOSTATA? Lesq.

FICUS PLANICOSTATA? Lesq., Newberry, Later Extinct Floras, p. 88, Pl. XLVI, fig. 1, 1898 (1899).

Locality.—Bridge Creek, Grant County, Oregon. Collected by Rev. Thomas Condon (U. S. Nat. Mus., No. 7084).

FICUS? OREGONIANA Lesq.

Pl. X, fig. 3.

FICUS? OREGONIANA Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 18, Pl. IX, fig 3, 1888.

As the original figure of this species is so poorly and even incorrectly drawn, I give another of the type specimen. As may be seen, Lesquereux's figure shows a curious prolongation on one side, but this has been greatly exaggerated. The specimen is a little broader on one side, but not to such an extent as might be inferred from the figure. The recent collections from the same locality contain a fine, nearly perfect example of this species, which shows it to be nearly equilateral.

Locality.—Van Horn's ranch, South Fork of John Day River, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., Nos. 2475, 8543) and Dr. John C. Merriam (Mus. Univ. Cal., No. 884).

ARTOCARPUS CALIFORNICA? Knowlton.

ARTOCARPUS CALIFORNICA Knowlton, Science, Vol. XXI, p. 24, Jan. 13, 1893.
Aralia pungens Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 16, 1888.
Myrica (*Aralia*) *Lessigii?* Lesq., idem., p. 16, 1888.

The collections made by Bendire contained three specimens that were referred by Lesquereux as above indicated. They are all very fragmentary and can not be made out with satisfaction, yet it is reasonably certain that only one species is represented, and in all probability they are the same as my *Artocarpus californica*. It was hoped that late collections from these beds might contain specimens that would clear up this question, but unfortunately they do not, and it must remain open to revision.

Artocarpus californica differs from *A. Lessigiana* (Lesq.), Knowlton, in its smaller size, thinner texture, and shorter, more acute lobes.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., Nos. 2428, 2522.)

Family BERBERIDACEÆ.

BERBERIS SIMPLEX Newb.

BERBERIS SIMPLEX Newb., Proc. U. S. Nat. Mus., Vol. V, p. 514,1883; Later Extinct Floras, p. 97, Pl. LVI, fig. 2, 1898 (1899).

The type of this very distinct species still remains unique.

Locality.—Bridge Creek, Grant County, Oregon. Collected by Rev. Thomas Condon (U. S. Nat. Mus., No. 7046).

BERBERIS? GIGANTEA n. sp.

Pl. XI, fig. 1.

Leaf of large size, very thick and leathery in texture, palmately deeply three-lobed, lobes lanceolate, provided with numerous, large, triangular or triangular-lanceolate, sharp-pointed lobes; lobes provided with very thick, fleshy midrib, and an apparently continuous intramarginal vein; secondary branches very thin, arising from the midrib and passing directly or with a slight curve to the apices of the lateral lobes; finer nervation very thin, anastomosing, producing large, irregular areas.

The single magnificent specimen upon which this opinion is based remains absolutely unique. It was clearly a thick, leathery leaf, and palmately deeply three-lobed. There is no means of knowing the full length and width, as both base and apex are absent. Of the middle lobe only about 6 cm. is preserved; of the lateral lobes 8 to 11 cm. is preserved. The widest part between the lobes as now preserved measures about 13 cm. When perfect it was probably at least 15 cm. long and spread probably 18 cm. The petiole is, of course, not preserved. The nervation, as set forth in the diagnosis, is strongly marked. There is a thin intramarginal vein running around the entire margin, this being especially prominent in the interval between the lateral lobes. Each lobe is provided with a very thick, fleshy midrib, from which arise, at irregular intervals, the thin secondaries which pass to the sharp points of the lateral lobes. The other nervation produces large anastomosing areas.

I am somewhat uncertain as to the proper generic reference for this fine leaf. The late Dr. Newberry, to whom the specimen was sent and who had prepared a drawing of it, placed it provisionally in the genus Cnicus, or Carduus, as it is now called. The peculiar sharp lobes, as well as the fleshy midribs, are suggestive of the large spiny leaves of thistles, but no species of this genus, so far as I know, has palmate leaves. The individual lobes resemble the whole leaf of many species of Carduus, but the palmate character effectively excludes it.

The only genus with which I have been able to satisfactorily compare this leaf is Berberis, and the nearest species is *B. trifoliolata* Moric. This species, now found in southern Texas and Mexico, has ordinarily small trifoliolate leaves, but occasionally one is found in which two and sometimes all three leaflets are united for a greater or less distance at the base, thus producing a leaf of exactly the same character as the fossil under discussion. The individual leaflets of this living species are rarely more than 4 cm. in length, whereas the lobes of this fossil form must have been 10 or 12 cm. long. In the matter of lobation, nervation, and general appearance, even to the intramarginal vein, the agreement between them is perfect. For this reason I have placed this fossil under Berberis and denoted the doubt by a question mark.

Locality.—Mascall beds, Van Horn's ranch, about 12 miles west of Mount Vernon, Oregon. Collected by Rev. Thomas Condon. The type and only specimen is the property of Columbia University, New York, and is under the care of the New York Botanical Garden.

Family MAGNOLIACEÆ.

MAGNOLIA LANCEOLATA Lesq.

MAGNOLIA LANCEOLATA Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 20, 1888.

Locality.—Cherry Creek, Crook County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2515).

MAGNOLIA CULVERI Knowlton.

MAGNOLIA CULVERI Knowlton, Mon. U. S. Geol. Surv. Vol. XXXII, Pt. II, p. 720, Pl. XCII, fig. 5, 1899.
Populus monodon Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 21, 1888.

This material is not very well preserved, but it agrees absolutely with this species and is so referred.

Locality.—Cherry Creek, Crook County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus.. No. 2546) and by Knowlton and Merriam in 1901 (U. S. Nat. Mus., No. 9058).

MAGNOLIA INGLEFIELDI Heer.

MAGNOLIA INGLEFIELDI Heer, Fl. Foss. Arc., Vol. I, p. 120, Pl. III, fig. 5c; Pl. XVI, figs. 5, 6, 8b; Pl. XVIII, figs, 1-3, 1868; Lesquereux, Proc. U. S. Nat. Mus., Vol. XI, p. 13, 1888.

This is certainly different from the last and may well be Heer's species. It is not contained in recent collections.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2513).

Family LAURACEÆ.

LAURUS OREGONIANA n. sp.

Pl. IX, figs. 2, 3.

Laurus n. sp., Knowlton in Merriam, Univ. Cal., Bull. Dept. Geol., Vol. II, No. 9, p. 309, 1901.

Leaves coriaceous in texture, narrowly lanceolate in shape, narrowed from apparently above the middle to a long narrowly wedge-shaped base (upper portion not preserved, but apparently long and narrowly acuminate); midrib thick below, becoming very slender in the upper portion; secondaries about 6 pairs, thin, alternate, arising at an acute angle, passing high up near the margin, where they join,

by a series of broad loops, the one next above; nervilles prominent, oblique to the midrib and mainly broken, producing large, irregular areas; finer nervilles numerous, very thin, oblique to the stronger ones; ultimate nervation made up of very minute but regular reticulations.

This species is represented thus far by only two specimens, the one figured and another much less perfect. The one shown in the plate was about 18 cm. long (13.5 cm. in length is now preserved), and 3.5 cm. wide at a point probably a little above the middle. It is impossible to estimate the length of the other specimens, but it is wider, being fully 4.5 cm. wide. The nervation differs slightly, also, the secondaries arise at a less acute angle, but otherwise there is no appreciable difference.

The affinity of the unfigured example seems to be with some forms of *Laurus californica* Lesq., but it differs in having the secondaries at a more acute angle of divergence and undoubtedly belongs with the leaf figured. It may also be compared with *Persea punctulata* Lesq.[a]

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Merriam's expedition of 1900 (Mus. Univ. Cal., No. 868).

Cinnamomum Dilleri Knowlton.

Cinnamomum Dilleri Knowlton, Twentieth Ann. Rept. U. S. Geol. Surv., Pt. III, p. 47, Pl. IV, fig. 1, 1900.

The material from Cherry Creek obtained in 1901 contains one nearly perfect example and several fragmentary specimens that must belong to this species. The most perfect specimen is slightly larger than the type, but otherwise there is no appreciable difference.

The type was described from Comstock, Douglas County, Oregon, in beds supposed to be Miocene in age, but associated with it were shells of *Cardita planicostata* and other characteristic Eocene fossils. As the beds at Cherry Creek are certainly Eocene it would seem to sustain the contention that the beds at Comstock are also of this age.

Locality.—Cherry Creek, Crook County, Oregon. Collected by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., Nos. 9055, 9056).

Cinnamomum Bendirei n. sp.

Pl. X, fig. 4.

Leaf membranaceous in texture, oblong-lanceolate in shape, long wedge-shaped at base, apparently rather obtusely pointed at apex; margin entire; petiole long and slender; midrib thick below, becoming very thin above, with two or three pairs of thin secondaries in the upper part which are at a low angle; lower pair of strong secondaries

[a] Proc. U. S. Nat. Mus., Vol. XI, p. 26, Pl. XIV, fig. 1, 1888.

arising at a point well above the base of the blade, passing up at an acute angle to near the upper part of the leaf, and here they become thin and join with the equally thin secondaries from the upper part of the midrib; each of the large secondaries with several thin loops on the outer side; nervilles numerous, thin, crossing between the midrib and strong secondaries, mainly percurrent though irregular; finer nervation producing rather large blocks.

The example figured is the only one found in the collections. It lacks only the extreme upper portion. The length was about 6.5 cm., exclusive of the petiole, which is 1.5 cm. in length. The width of the blade is 2.5 cm. at the broadest point, which is slightly above the middle.

This species is wholly unlike anything before reported from the beds at Bridge Creek. It is perhaps nearest to certain forms of *C. Scheuchzeri* of Heer, being, for example, hardly to be separated from a leaf figured by Ludwig[a] in his Fossile Pflanzen aus der ältesten Abtheilung der Rheinisch-Wetteraurer Tertiär-Formation. This, however, is not the typical form of *C. Scheuchzeri*, and I prefer to describe it as new rather than unite it with an anomalous leaf that has been referred to an established species.

Locality.—Bridge Creek, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 8490).

Family HYDRANGEACEÆ.

HYDRANGEA BENDIREI (Ward) Knowlton.

Pl. IX, figs. 6, 7.

HYDRANGEA BENDIREI (Ward) Knowlton in Merriam, Univ. Cal., Bull. Dept. Geol., Vol. II, No. 9, p. 309, 1901.

Marsilea Bendirei Ward, Fifth Ann. Rept. U. S. Geol. Surv., p. 446, 1885.

Porana Bendirei (Ward) Lesquereux, Proc. U. S. Nat. Mus., Vol. XI, p. 16, Pl. VIII, fig. 4, 1888.

Sterile flowers of large size; calyx lobes of firm texture, broadly obovate, oval, or nearly circular in shape, considerably overlapping, obtuse and rounded at apex, truncate or slightly narrowed at the sessile base; nervation strong, consisting of some six or eight nerves of equal strength, the central one passing apparently to the tip of the calyx lobes and having two or three branches at various distances which anastomose with it some distance below the apex; other nerves diverging and joining by broad loops with several series of smaller loops outside; nervilles producing quite large irregularly quadrangular areas in which there are often free veins.

[a] Palæontographica, Vol. VIII, Pl. XLI, fig. 8.

Four more or less perfect examples of this exceedingly interesting species have been found. The original specimen is nearly 4 cm. by 3 cm. in size, the large sepals being 2 cm. long and 1.5 cm. broad. The next discovered specimen was obtained by Dr. John C. Merriam in 1900. It is not quite perfect, but has the nervation very well preserved. The sepals are about 2 cm. long and nearly as broad. The two remaining examples were obtained by myself in 1901.

The original specimen, as may be noted under the synonymy, was first tentatively referred to Marsilea, and was later placed under Porana by Lesquereux, who correctly recognized its nature. Lesquerex, however, was in error in supposing that the sepals were "connate to above the middle." They are undoubtedly free and overlapping, as shown by the present drawing. (See Pl. IX, fig. 6.) The example secured by Dr. Merriam is, as already stated, not perfectly preserved, but as nearly as can be made out, it consists of only three sepals, although the fourth may be present, concealed under the others. They are clearly free, however.

The fossil forms referred to Porana consist of the more or less leathery sepals and are usually five in number. Two species have been described from the United States by Lesquereux, both coming from Florissant, Colorado. *Porana Speirii*[a] is a five-lobed connate species, while *P. tenuis*[b] has never been figured, but is described as having the sepals separate to the base. The first is very distinct from the form under consideration, while the latter can not be well compared.

On first examining these specimens, especially the one collected by Dr. Merriam (Pl. IX, fig. 7), they seem to be referable to a Cornus of the type of *C. florida* or *C. Nuttallii* Aud., but the absence of any marked indication of the flowers in the center apparently precludes their reference to this genus.

At the suggestion of Mr. Charles Louis Pollard, of the United States National Herbarium, these fossils were compared with various species of the genus Hydrangea, and the resemblance between them and the sterile flowers so characteristic of this genus was so striking that they have been referred to Hydrangea.

Eight fossil species of Hydrangea have been described from the European Tertiary, but none of them approach closely to our form.

Locality.—Van Horn's ranch, South Fork of John Day River, 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 8515), and by Dr. John C. Merriam (Pal. Col. Univ. Cal., No. 854). Also obtained from a gulch half a mile northwest of the Belshaw ranch, the next ranch east of Van Horn's, by F. H. Knowlton, July, 1901 (U. S. Nat. Mus., Nos. 8994, 8995).

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[a] Cret. and Tert. Fl., p. 172, Pl. XXVIII, fig. 15, 1883.

[b] Idem, p. 173.

Family HAMAMELIDACEÆ.

LIQUIDAMBAR EUROPÆUM Al. Br.

LIQUIDAMBAR EUROPÆUM Al. Br. Newberry, Later Extinct Floras, p. 100, Pl. XLVII, figs. 1–3, 1898 (1899).

As Newberry well says (op. cit. p. 101), this species is hardly to be distinguished from large leaves of Lesquereux's *Liquidambar californicum*, from the Auriferous gravel of California. But it appears that the large form is rare among the Auriferous gravel examples, most of them being much smaller and only three lobed. It therefore seems best to keep them apart for the present, although they are undoubtedly close. Its identity with the European form is also a matter for future settlement.

Locality.—Bridge Creek, Grant County, Oregon. Collected by Rev. Thomas Condon (U. S. Nat. Mus., Nos. 7094, 7095, 7096).

LIQUIDAMBAR EUROPÆUM PATULUM, n. var.

Pl. X, fig. 5.

Liquidambar europæum Al. Br. Lesquereux, Proc. U. S. Nat. Mus., Vol. XI, p, 14, 1888.

This specimen, the only one thus far found at this locality, was referred by Lesquereux, without comment, to *L. europæum.* It is a well-known fact that this is a very variable species, which more than likely covers several distinct forms, but the leaf under consideration differs markedly from any that I have seen figured in European books. It is distinctly different from the large five- to seven-lobed leaves found at Bridge Creek, nor is it the same as Lesquereux's *L. californicum*, from the Auriferous gravels. I have therefore ventured to give it subspecific rank under the name of *L. europæum patulum.* It may be described as follows: Leaf coriaceous in texture, three-lobed and much broader than long; central lobe obtusely elliptical; lateral lobes lanceolate-acuminate, nearly at right angles to the central lobe; margin finely and sharply serrate throughout.

The width of this leaf is about 14 cm. and the length only about 8 cm. The central lobe is about 4 cm. broad and the same in length, while the lateral lobes are but little more than 2.5 cm. broad.

Locality.—Van Horn's ranch, South Fork of John Day River, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 8544).

LIQUIDAMBAR PROTENSUM ? Unger.

LIQUIDAMBAR PROTENSUM ? Unger. Lesquereux, Proc. U. S. Nat. Mus., Vol. XI, p. 13, Pl. VIII, fig. 3, 1888.

I regard this identification as extremely doubtful. The specimen lacks practically all of the margin, and other of its characters have

been distorted. As Lesquereux suggests (op. cit., p. 13), this leaf has a striking resemblance to his *Acer dimorphum*, but the specimen is not sufficiently perfect to warrant the assertion that it represents a leaf of that species.

Locality.—Van Horn's ranch, South Fork of John Day River, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2504).

LIQUIDAMBAR PACHYPHYLLUM, n. sp.

Pl. IX, fig. 1.

Leaf of small size, very thick in texture, five-lobed, the lobes short, ovate, or ovate-lanceolate, acute; margin serrate throughout, the teeth rather large, upward pointing; ribs arising just inside the lower margin of the blade, very strong, passing to the apices of the lobes; secondary branches numerous, alternate, often irregular, camptodrome, arching near the margin; nervilles very irregular, producing a coarse, heavy network.

The single broken example figured is all that was found in the collections. It was clearly five-lobed, but only the two lower and a part of one middle lobe is preserved. The total length appears to have been between 5 and 6 cm., or possibly a little more. The width between the two lower lobes is 5.5 cm.

This species had evidently a very thick, pulpy leaf, and the nervation is especially strong, particularly the ribs and nervilles.

Leaves of this genus appear to be rare in the Mascall beds, and the leaf under consideration is wholly unlike any before detected. The leaves referred to *L. europæum patulum* and *L. protensum* are thin, being like the living species in texture, whereas ours is clearly a thick leaf with a strong nervation. It is also unlike *L. californicum*, from the Auriferous gravels.

Locality.—Mascall beds, Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., No. 8534).

LIQUIDAMBAR sp.?

Pl. XII, fig. 4.

The collection contains one leaf that apparently belongs to Liquidamber, but it is much broken, and does not show all the characters. This example, shown in Pl. XII, fig. 4, is a large leaf, five or possibly seven lobed, the lower lobes being at right angles with the midrib, producing a novel truncate base. The width between these two lobes is nearly 14 cm. The margin of the lobes is provided with numerous fine teeth. The nervation is well marked, consisting of about five strong ribs, which radiate from the top of the petiole and presumably end

in the tips of the lobes. Each is provided with numerous secondary branches, and from the larger size of some it is presumed that they supplied lateral lobes. The finer nervation is that of Liquidambar.

Locality.—White hill one-half mile east of original Van Horn's ranch locality. Collected by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., No. 8545).

Family PLATANACEÆ.

PLATANUS ASPERA Newb.

PLATANUS ASPERA Newb., Proc. U. S. Nat. Mus., Vol. V, p. 509, 1883; Later Extinct Floras, p. 102, Pl. XLII, figs. 1–3; Pl. XLIV, fig. 5; Pl. LIX, fig. 3, 1898.

The types of this species are before me, together with a number of more or less fragmentary examples collected later. They exhibit nothing to modify the views originally expressed by Newberry.

Locality.—Bridge Creek, Grant County, Oregon. Collected by Rev. Thomas Condon (U. S. Nat. Mus., Nos. 7079, 7081, 7082, 7083) and Maj. Charles E. Bendire (U. S. Nat. Mus., No. 3010).

PLATANUS CONDONI (Newb.) Knowlton.

PLATANUS CONDONI (Newb.) Knowlton in Merriam, Univ. Cal., Bull. Dept. Geol., Vol. II, No. 9, p. 289, 1901.

Ficus? Condoni Newb., Proc. U. S. Nat. Mus., Vol. V, p. 512, 1883; Later Extinct Floras, p. 85, Vol. LVI, fig. 1; Pl. LVIII, fig. 1, 1898.

The following conclusions are based on all of the original types of Newberry, together with a considerable number more recently collected, which have passed through Lesquereux's hands. Newberry, as evidenced by the question mark placed after the genus as well as the discussion in the Later Extinct Floras, was in doubt as to the reference of these fine leaves to the genus Ficus, and Lesquereux referred them without hesitation to *Platanus basilobata.* That it should be placed in the genus Platanus is certain, but that it should be referred to Professor Ward's species is not quite so clear. After a careful examination of the types of *Platanus basilobata* and consultation with their author, I can but conclude that, although close, there are sufficient differences to warrant keeping them apart, at least for the present. The basal lobes in *P. basilobata* are uniformly larger, and in most cases several times the size of those in the form under discussion, and, moreover, they appear to be always deeply lobed in the former and entire in the latter. Assuming that the evolutional tendency is to get rid of these large stipular organs, as suggested in the living *P. occidentalis*, the Bridge Creek form would represent a more recent and higher developed stage than *P. basilobata*, a supposition

borne out by the relative ages of the beds in which they are found. In size of blade, configuration of margin, and in nervation the two forms are practically identical.

Localities.—Bridge Creek, Grant County, Oregon. Collected by Rev. Thomas Condon (Newberry's types, U. S. Nat. Mus., Nos. 7079, 7085) and Maj. Charles E. Bendire (U. S. Nat. Mus., Nos. 2892, 2898). Officer's ranch, lower end of Butler Basin. Collected by Dr. John C. Merriam, July 22, 1901 (U. S. Nat. Mus., No. 9206–9208).

PLATANUS NOBILIS? Newb.

PLATANUS NOBILIS? Newb. Lesquereux, Proc. U. S. Nat. Mus., Vol. XI, p. 19, 1888.

The material from Van Horn's ranch contains a single very large leaf which Lesquereux identified with this species. This particular specimen lacks most of the margin, but as nearly as can be made out it was five-lobed and entire, or at most only undulate on the margin. In size it must have been more than 25 cm. long and 23 cm. or more broad. The petiole is preserved entire and is 8 cm. long and 7 mm. thick at the point of attachment to the branch and 4 mm. thick in the middle. The nervation of the leaf is strong. The margin not having been preserved it is hard to be positive of this determination, yet, all things considered, it is possibly correct, although the petiole is stronger than I remember to have seen in this species. Additional material must be awaited for satisfactory settlement.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2538).

PLATANUS ACEROIDES? (Göppert) Heer.

PLATANUS ACEROIDES (Göppert) Heer. Lesquereux, Proc. U. S. Nat. Mus., Vol. XI, p. 19, Pl. V, fig. 7, 1888.

The two examples identified by Lesquereux as this species are very unlike in size, the smaller—the one figured—being 4 cm. long and a little more than 3.5 cm. broad, while the larger one is 11 or 12 cm. long and 13 cm. or more broad. I am uncertain as to the correctness of this identification. They do have somewhat the appearance of various leaves that have been referred to this species, but they also differ. There is not a sufficient amount of material, however, to warrant attempting to properly characterize them as new. I have therefore retained them as above, with the mark of interrogation after the specific name.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2535).

PLATANUS sp.

Platanus Raynoldsii Newberry. Lesquereux, Proc. U. S. Nat. Mus., Vol. XI, p. 19, 1888.

This identification rests on two fragments of very large leaves that are not in my opinion well enough preserved to warrant specific determination. They can hardly belong to *P. Raynoldsii*, as Lesquereux has stated, nor do they seem to be parts of either *P. nobilis* or *P. aceroides*. Just what they are I am unable to say at present.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2539).

Family ROSACEÆ.

CRATÆGUS FLAVESCENS Newb.

Pl. X, fig. 1.

CRATÆGUS FLAVESCENS Newb., Proc. U. S. Nat. Mus., Vol. V, p. 507, 1883; Later Extinct Floras, p. 112, Pl. XLVIII, fig. 1, 1898.
Myrica diversifolia Lesq., Cret. and Tert. Fl., p. 241, Pl. L, fig. 10, 1883.

I have before me as I write the type of Newberry's *Cratægus flavescens* (U. S. Nat. Mus., No. 7088) and a part of Lesquereux's types of his *Myrica diversifolia* as described first from Florissant, Colorado. The type of the Bridge Creek example referred by Lesquereux to *M. diversifolia* (op. cit., Pl. L, fig. 10) is in the paleontological collection of the University of California, where I have seen it, and there can be no doubt of its absolute identity with Newberry's *Cratægus flavescens* of prior date, and I have so referred it. In regard to the status of the Florissant specimens[a] I am somewhat in doubt. The National Museum collection does not appear to contain all of the figured examples and, judging from the figures alone, it would seem that they represent more than one species. Figs. 7, 8, 11, 12, and 14 are seemingly identical with the Bridge Creek species, yet they show a tendency to have sharply toothed lobes, a condition not often present in the former species. In the absence of a sufficient amount of material (these leaves appear to be rare in the Bridge Creek collections) it has seemed best to leave it for future settlement.

Locality.—Bridge Creek, Grant County, Oregon. Collected by Rev. Thomas Condon and Maj. Charles E. Bendire (U. S. Nat. Mus., No. 8489). Type of Lesquereux's fig. 10, op. cit., in Mus. Univ. Cal., No. 1757.

CRATÆGUS IMPARILIS n. sp.

Pl. X, fig. 2.

Leaf semicoriaceous, roughly ovate in outline, very obtusely wedge-shaped at base, palmately three-ribbed, primarily three-lobed, but

[a] Cret. and Tert. Fl., p. 148, Pl. XXV, figs. 6–15.

ultimately seven-lobed; lateral lobes of same size, separated from central lobe by sharp, deep sinuses, rather obtuse at apex, each with a single, small, obtuse lateral lobe; central lobe much the larger, lanceolate, three-lobed at apex, secondary lobes short acute; margin of lobes undulate or obscurely dentate; the three ribs of about the same size, the central or midrib with about six pairs of alternate, thin secondaries, two of which enter the lateral lobes; lateral ribs with several pairs of thin, irregular secondaries, two of which are slightly larger and enter the side lobes; finer nervation producing a regular, deeply impressed network.

The leaf figured, the only one found, is 3 cm. long and about 2 cm. wide. It is seven-lobed, but only three-ribbed, the lower lobes each have a small side lobe, and the main central lobe a small lobe on each side. The length of the lower lobes from the sinus is about 1 cm. that of the middle lobe from the sinus is 1.75 cm. The configuration of the margin and the nervation are well shown in the figure.

This species appears to find its closest affinity with *Cratægus flavescens* Newb.,[a] or *Myrica diversifolia*, as it was later called by Lesquereux.[b] The leaf from Bridge Creek, referred by Lesquereux to his *Myrica diversifolia*, is certainly the same as Newberry's *Cratægus flavescens*, and certain of the Florissant leaves appear to be the same, but I am under the impression that at least two species are represented in the latter material.

The leaf under consideration differs in a number of particulars from the Bridge Creek specimens. Thus it is deeply three-lobed with each lateral lobe provided with a small lobe, whereas the Bridge Creek specimens are usually rather evenly lobed throughout. The ribs in the new form are three in number and arise at the top of the petiole. In the other species the leaf is not palmately ribbed, but is provided with secondaries, even the lowest pair of which arise from the midrib well above the base and pass to the lobes. The margin of these latter specimens inclines to be more crenulate. One specimen is perhaps closer in shape to one of the Florissant leaves,[c] but it differs in the nervation in the same manner as do the other examples.

Locality.—White hill half-mile east of original Van Horn's ranch locality. Collected by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., No. 8513.)

PRUNUS? MERRIAMI n. sp.

Pl. XI, figs. 2, 3, 6, 7.

Prunus n. sp., Knowlton in Merriam, Univ. Cal., Bull. Dept. Geol., Vol. II, No. 9, p. 309, 1901.

Leaves coriaceous, ovate in shape, apparently abruptly rounded and truncate at base, obtusely acuminate at apex; margin finely serrate,

[a] Later Extinct Floras, p. 112, Pl. XLVIII, fig. 1.

[b] Cret. and Tert. Fl., p. 241, Pl. L, fig. 10. This species was also described and figured from Florissant, Colorado, Idem, p. 148, Pl. XXV, figs. 6–15.

[c] Idem, Pl. XXV, fig. 11.

the teeth of nearly equal size, obtusely pointed; midrib very thick, especially below; secondaries about ten pairs, mostly strong, alternate or a few opposite, arising nearly at a right angle on one side and at an angle of about 20° or 25° on the other, strongly camptodrome, arching far below the margin and joining the secondary next above by a broad loop, with a series of loops on the outside from which nervilles enter the teeth; nervilles numerous, strong, irregular, often broken, producing large areas which are filled by a very regular fine network.

The type of this species is nearly 4 cm. in length and is a little more than 2.5 cm. in width. It appears to have been a rather thick leaf, ovate in shape, with a finely serrate margin, a thick midrib, and about ten pairs of strong, camptodrome secondaries, which divide and arch far inside the margin.

While I am not absolutely certain that this leaf should properly be referred to Prunus, it agrees so closely in a general way with various living species of this genus that it has been tentatively placed under it. It is, for instance, very similar to certain forms of *P. virginiana*, *P. demissa*, etc. It is also quite like some species of Cydonia, as *C. japonica*, the flowering quince, but it is hardly likely that this genus was natural to this country. In any case the species is a well marked one and can readily be identified as a stratigraphic mark.

This species is named in honor of Dr. John C. Merriam, of the University of California.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Merriam's expedition of 1900 (Mus. Univ. Cal., Nos. 886, 887) and by Knowlton and Merriam, 1901 (U. S. Nat. Mus., No. 8514).

PRUNUS? TUFACEA n. sp.

Pl. XI, fig. 4.

Prunus n. sp., Knowlton in Merriam, Univ. Cal., Bull. Dept. Geol., Vol. II, No. 9, p. 309, 1901.

Leaves semicoriaceous in texture, elliptical or elliptical-obovate, slightly unequal sided, rather abruptly wedge shaped at base, and similarly narrowed at apex; margin finely, sharply, and evenly serrate throughout; petiole thick and strong; midrib rather thick, especially below; secondaries about eight or nine pairs, opposite in the lower portions, alternate above, arising at an angle of about 30° or less and camptodrome, forking well below the margin and joining the one next above by a broad loop, and apparently with thin nervilles passing to the teeth; nervilles strong, mainly broken; finer nervation producing minute areolæ.

These leaves are about 3.5 cm. long and 2 cm. broad. The thick petiole is over 1 cm. long. The marginal teeth are fine, regular, and sharp pointed.

These leaves may belong to the preceding species, but as they differ in a number of minor particulars it has seemed best to keep them separate. They are elliptical or slightly elliptical-obovate instead of ovate, the teeth are finer, more regular, and evidently sharper pointed, and the secondaries are at a stronger angle of divergence.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Merriam's expedition of 1900. (Type in Mus. Univ. Cal., No. 885.)

Family MIMOSACEÆ.

ACACIA OREGONIANA Lesq.

ACACIA OREGONIANA Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 14, Pl. V, fig. 4, 1888.

The type specimen with its counterpart still remains unique.

Locality.—Van Horn's ranch, South Fork of John Day River, 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2412).

Family CÆSALPINACEÆ ?

CASSIA ? sp. Newb.

CASSIA? sp., Newb., Later Extinct Floras, p. 113, Pl. XLVI, fig. 10, 1898.

The type of this form is before me and it requires but a glance to see that the drawing does not correspond accurately with the specimen. Judging from the drawing alone it would seem to represent a small leguminous pod with faint depressions corresponding to the places occupied by the seeds. The outer surface is represented as uniform and unmarked. The specimen itself does not show any evidence of the presence of seeds, and the outer surface is strongly marked with close parallel lines which are oblique to the long direction and which completely cross it from side to side. I do not understand this structure, and while it may represent a small pod it is hardly probable that it is a Cassia.

Locality.—Bridge Creek, Grant County, Oregon. Collected by Rev. Thomas Condon (U. S. Nat. Mus., No. 7093).

Family SIMARUBACEÆ.

AILANTHUS OVATA Lesq.

AILANTHUS OVATA Lesq., Cret. and Tert. Fl., p. 254, Pl. LI, figs. 7, 8, 1883.

The type specimens only are known. I have examined these specimens, both being preserved on the same piece of matrix. The figure of the branch shows the buds much clearer than they appear on the specimen, but it is perhaps correctly referred. The samaras are

described by Lesquereux as being rounded at one end and acute at the other. An examination shows that the bluntness described is due to the ends of one or two being broken or covered by matrix, while in one well preserved both ends are similar and acute.

Locality.—Bridge Creek, Grant County, Oregon. Collected by C. D. Voy. (Types in Mus. Univ. Cal., Nos. 1765, 1766.)

Family ANACARDIACEÆ.

RHUS BENDIREI Lesq.

RHUS BENDIREI Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 15, Pl. IX, fig. 2, 1888.

The type material consisted of the example figured and another specimen with its counterpart. The figured specimen, it will be noted, is oblanceolate in shape, about 10.5 cm. in length, 3.5 cm. in width at the broadest point, and is narrowly wedge-shaped below and acuminate above. Lesquereux regarded this as the terminal leaflet and decided that the other specimen represented a lateral leaflet of the same species. Of this latter he says: "To this I refer a small, oblong-lanceolate leaflet, rounded in narrowing rapidly to the point of attachment, very short-petioled, and areolation identical." This is much smaller, being only 6 cm. in length and 2.5 cm. in greatest width, and while it looks at first quite different, may belong to it. The collection made by Dr. John C. Merriam in 1900 contains two specimens like the smaller leaflet.

Locality.—Van Horn's ranch, South Fork of John Day River, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2582).

RHUS ? sp. Lesq.

Pl. XIV, fig. 6.

The original collection by Bendire contains a fragment of the base of a leaf or leaflet that was referred by Lesquereux to Rhus, but was not included in his published list of species. It is impossible to make out the whole outline, but it seems to have been obovate with a broadly wedge-shaped, unequal-sided base. The margin appears to have been provided with small, sharp teeth. The nervation consists of a comparatively thick midrib and quite a number of thin secondaries, those on the broader side of the blade being at a right angle and those on the narrower side at an angle of about 40°. They are apparently camptodrome.

It is clearly unsafe to attempt comparisons between this specimen and other known species.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 8550).

Family CELASTRACEÆ.

CELASTRUS DIGNATUS n. sp.

Pl. XI, fig. 5.

Leaves membranaceous, elliptical, or slightly obovate-elliptical in shape, truncate, or very obtuse and somewhat unequal-sided at base, truncate at apex; margin coarsely toothed, the teeth obtuse, upward pointing; petiole short and thick; midrib thick; secondaries about 10 pairs, alternate, at a low angle, craspedodrome, passing to the marginal teeth; nervilles numerous, mainly unbroken, at right angles to the secondaries; finer nervation, producing numerous small, irregularly quadrangular meshes.

Several specimens represent this species, all being of about the same size. They are in general elliptical-obovate, very obtusely wedge-shaped or truncate at base and rounded at apex. They are 4 cm. in length and 3 to 3.5 cm. in width. The petiole, preserved in only one example, is 5 mm. long and 2 mm. thick at the point of attachment. The toothed margin and characteristic nervation are well shown in the figures.

This species seems to have some affinity with *Celastrus inæqualis* Knowlton[a] from the Fort Union beds in the Yellowstone National Park. This differs, however, in being a much larger leaf, toothed only above the lower third of the blade, the teeth being also more obtuse. The general appearance of the two species, however, is strikingly similar.

Locality.—Mascall beds, Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., No. 8539).

CELASTRUS CONFLUENS, n. sp.

Pl. II, figs. 1-3.

Leaves membranaceous, elliptical in shape, wedge-shaped and slightly unequal-sided at base, obtuse but not truncate at apex; margin toothed, the teeth quite large, sharp pointed; midrib strong; secondaries, about twelve pairs, mainly alternate, at an angle of about 45° on one side of the blade and nearly a right angle on the other, camptodrome, arching very near the margin or forking and sending branches to the teeth; nervilles and finer nervation as in the last species.

This form is represented by several quite perfect leaves, which may possibly belong to the last species, but they are much larger and are unaccompanied by examples of intermediate size, so that it has seemed best to give them tentatively a new name. The best preserved example, which is also the largest, is 9 cm. long and 5 cm. wide. The

[a] Mon. U. S. Geol. Surv., Pl. XCVIII, fig. 3.

smallest example was apparently about 8 cm. long and is a little over 4 cm. wide.

Locality.—Mascall beds, Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Merriam and Knowlton, July, 1901 (U. S. Nat. Mus., No. 8578).

Family ACERACEÆ.

ACER OSMONTI n. sp.

Pl. XIII, fig. 3.

Leaf membranaceous, five-lobed from the top of the petiole, lower pair of lobes small, at right angles to the midrib, other pair large, at an angle of 45° with the midrib; central lobe evidently largest of all (mainly destroyed); all lobes irregularly toothed and lobed, the lobes sharp pointed; petiole very long and strong; nervation palmately five-ribbed, the ribs ending in the main lobes, each with several pairs of alternate secondaries which emerge at an acute angle and terminate in the teeth of small lateral lobes; nervilles numerous, rather thin, mainly percurrent and crossing approximately at right angles to the secondaries; finer nervation producing rather large areolæ.

The genus Acer seems to be quite rare in the Bridge Creek beds, although abundantly represented in the Mascall beds at Van Horn's ranch and vicinity. All that I have thus far seen is the leaf here described, a fragment of another, and less than half a dozen fruits. The one under consideration lacks the major portion of the central lobe and the terminal portion of one of the large lateral lobes. It spreads about 8 cm. between the points of the lower lobes and about 11 cm. between the points of the larger lobes. The length of the leaf can not be determined, but it can hardly have been less than 9 or 10 cm. The petiole, very thick and stout for the size of the blade, has 4 cm. of its length retained and was evidently somewhat longer.

This leaf has a very modern appearance, much more so, in fact, than the forms found in the Mascall beds. It suggests at once the sugar maple (*Acer saccharum* Marshall) of the East and is not greatly unlike small leaves of *A. macrophyllum* Pursh, the common maple of the west coast.

This species is named in honor of Mr. V. C. Osmont, of the University of California, who collected it.

Locality.—Bridge Creek, Oregon. Collected by Merriam's party in 1900. (Type in Mus. Univ. Cal., No. 2505.) The fragmentary leaf above described is No. 8488 in the U. S. Nat. Mus. It was collected by Condon.

Acer sp., Knowlton.

Pl. XIII, figs. 1, 2.

Acer sp., Knowlton, in Merriam, Univ. Cal., Bull. Dept. Geol., Vol. II, No. 9, p. 289, 1901.

A fragment of a small, three-lobed leaf showing a portion of the base, one lateral lobe, and a part of the central lobe. The length appears to have been about 5 cm. and the width between the lobes about 5.5 cm. It is coarsely toothed.

Another fragment from the same locality has the base with a short portion of the petiole preserved. It appears to be the same as the other.

Locality—One and one-half miles east of Clarnos Ferry. Collected by Merriam's expedition of 1900. Types in Mus. Univ. Cal. Nos. 900, 932.

Acer Bendirei Lesq.

Acer Bendirei Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 14, Pl. V, fig. 5; Pl. VI, fig. 1; Pl. VII, fig. 1; Pl. VIII, fig. 1, 1888.

Acer trilobatum productum (Al. Br.) Heer. Lesquereux, Cret. and Tert. Fl., p. 253, Pl. LIX, figs. 1, 2, 4 (non fig. 3, which is *Platanus dissecta* Lesq.).

This species, as may be seen from the above synonymy, was first regarded by Lesquereux as referable to the European *A. trilobatum productum*, but later was raised to full specific rank. This name was also applied to several leaves from Carbon, Wyoming,[a] but they are clearly not the same as those under consideration. In the Cretaceous and Tertiary Floras (p. 253), Lesquereux records the specimens under discussion as coming from "Currant Creek, John Day Valley, Oregon." This is in error, as the types are preserved in the paleontological collection of the University of California (Nos. 1797, 1797a, 1797b), and are seen at once to have come from Van Horn's ranch. They are in the characteristic white volcanic tuff, and not the hard, brownish matrix of the Current Creek deposits.[b]

Locality.—Van Horn's ranch, South Fork of John Day River, 12 miles west of Mount Vernon, Grant County, Oregon. Original material collected by C. D. Voy about 1870 (Mus. Univ. Cal., Nos. 1797, 1797a, 1797b); since collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2413), Dr. John C. Merriam (Mus. Univ. Cal., Nos. 850, 851), and F. H. Knowlton (U. S. Nat. Mus., Nos. 8940–8948).

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[a] Tert. Fl., p. 261, Pl. XLVIII, figs. 2, 3a, 1878.

[b] On Pl. LIX of the Cretaceous and Tertiary Floras, Lesquereux gives four figures which he refers to *Acer trilobatum productum* (now *A. Bendirei*), and all the specimens are said to be from the same locality, namely, "Currant Creek, Oregon." This is in error in regard to fig. 3, the original of which is preserved with the others in the Paleontological Collection of the University of California (No. 1835). This fragment was found to fit into and form a part of the same individual that is figured in the Auriferous gravel flora (Pl. V, fig. 3) under the name of *Aralia Zaddachi?* Heer. And further it was found that when so fitted together they produce a leaf that must be referred to *Platanus dissecta*. The locality, plainly marked on the back of each fragment, is Table Mountain, California.

ACER DIMORPHUM Lesq.

ACER DIMORPHUM Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 15, Pl. IX, fig. 1, 1888.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2415).

ACER MERRIAMI n. sp.

Pl. XIV, fig. 7.

ACER n. sp., Knowlton in Merriam, Univ. Cal., Bull. Dept. Geol., Vol. II, No. 9, p. 309, 1901.

Leaf coriaceous in texture, palmately deeply three lobed, the lobes broad, roughly ovate in shape, of approximately the same size, lateral lobes at a low angle with the central lobe; all margin coarsely and irregularly toothed, being provided with low, irregular, mostly sharp-pointed teeth; petiole long, very thick; midrib thick, with six or more pairs of alternate, strong secondaries which end in the large teeth of the central lobe, and have smaller branches which pass to other marginal teeth; lateral ribs nearly as strong as the midrib, at a low angle, each with about seven pairs of alternate secondaries passing to the large teeth, and those on the lower side especially with short branches, which end in marginal teeth; nervilles numerous, thin, mainly percurrent and at right angles to the secondaries; finer nervation forming a rather coarse, irregularly quadrangular network.

The example figured is the only one that has thus far been found. It is a large, deeply three-lobed leaf about 12 cm. long, exclusive of the petiole (of which 2.5 cm. in length is preserved), and about 14 cm. broad. All three lobes are of approximately the same size, and all are irregularly toothed, the margin being provided with low, sharp-pointed teeth. The nervation is beautifully preserved.

Maples are abundant in these beds, and many leaves, fruits, and branches have been obtained. The leaf under consideration is markedly different from *Acer Bendirei*, which is perhaps the most abundant species present, but may possibly be a very broad, coarsely toothed form of *A. dimorphum*. The latter species is described by its author as being prolonged at base into two small lobes which open like wings on each side of the midrib. The lateral ribs, therefore, arise at some distance above the top of the petiole in the broad, basal portion of the blade. In the leaf before me there is no indication of the basal lobes that are so conspiuous in *A. dimorphum*, and the ribs appear to arise at the top of the petiole and at the very base of the blade. Further, the lobes are doubly dentate—that is, have large, irregular teeth or lobes, the margins of which are provided with low teeth. Therefore it seems most logical to regard them as distinct, at least for the present.

This species is not greatly unlike some forms of *Acer trilobatum tricuspidatum* Heer[a] of the Swiss Miocene.

I take great pleasure in naming this species in honor of Dr. John C. Merriam, who has done so much for the paleontology of this region.

Locality.—Van Horn's ranch, South Fork of John Day River, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Merriam's expedition of 1900. (Type in Mus. Univ. Cal., No. 869.)

ACER, branches of?

ACER, branches of? Lesquereux, Proc. U. S. Nat. Mus., Vol. XI, p. 15, 1888.

A number of branches supposed to belong to some species of Acer, but it is quite impossible to determine which one.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2418).

ACER OREGONIANUM n. sp.

Pl. XIII, fig. 5–8.

Acer, fruits of, Lesquereux, Proc. U. S. Nat. Mus., Vol. XI, p. 15, Pl. VI, figs 2, 3, 1888.

Fruits long and broad-winged, the wing being evidently very thick and provided with numerous strong veins; nucleus large, round, showing broad truncation where attached to the sister fruit.

This form is so very abundant in all collections from these beds and admits so readily of separation that I have ventured to give it a name. It of course represents the fruit of one of the species founded on leaves that are also abundant in all collections, but thus far no fruit has been found attached to or even approximate to a leaf, and until so found it is more convenient to be able to refer to the fruits independently.

These fruits are, with the exception of that of *Acer gigas* (supra, p. 76), the largest ones found in these beds. They range in length from 3.5 to 4.5 cm. The wing is unusually broad, being not infrequently 1.75 cm. wide. It is filled with numerous strong veins, which are given off from the axis of the fruit in groups or bundles.

As Lesquereux has well suggested, these fruits most closely resemble those of the living *Acer macrophyllum* Pursh, the large-leaved maple so common on the Pacific coast; in fact, they are hardly to be distinguished.

Locality.—Abundant in Mascall beds at Van Horn's ranch and vicinity. All collectors have obtained it. Types of Lesquereux's figures in U. S. Nat. Mus., No. 2417. Types of figures in this paper collected by Knowlton and Merriam, July, 1901, in U. S. Nat. Mus., Nos. 8494–8497.

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[a] Fl. Tert. Helv., Vol. III, Pl. CXII, fig. 3.

ACER MEDIANUM n. sp.

Pl. XIV, figs. 4, 5.

Fruit large, lanceolate in shape; wing relatively narrow, filled with thin veins; nucleus round or oblong, the scar of attachment to its sister fruit very oblique.

This provisional species is represented by the two examples figured. The smaller is 4.25 cm. long and has the wing 1 cm. wide; the other is 4.75 cm. long and has a wing 1.25 cm. wide.

It is possible that there are merely very large fruits of the following species, as they are of approximately the same shape, but there are no intermediate specimens, and I have preferred to keep them separate for the present.

Locality.—Figure 4, the smaller, is from the original Van Horn's ranch locality; the other is from the white hill, one-half mile east of the first locality. Collected by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., Nos. 8498, 8499).

ACER MINOR n. sp.

Pl. XIV, figs. 2, 3.

Acer, fruits of, Lesquereux, Proc. U. S. Nat. Mus., Vol. XI, p. 15, Pl. VII, fig. 2, 1888.

Fruits of small size, similar in shape to the preceding species; length, 2.5 cm., width of wing, 8 mm.

As already stated, this may be the same as the preceding form, but the specimens are so much smaller, and moreover, as there are no intermediate specimens, it has seemed best to regard them as distinct.

Inasmuch as three species have been differentiated in these beds, based on leaves, it is natural to suppose that the fruits might also show differences, In any case it would seem easy to recognize the three forms of fruits here described.

Locality.—White hill one-half mile east of original Van Horn's ranch locality, Grant County, Oregon. Collected by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., Nos. 8500, 8501).

ACER GIGAS n. sp.

Pl. XIV, fig. 1.

Fruit of enormous size, very narrow; wing of nearly similar width throughout, filled with numerous but rather fine veins; nucleus very large, elliptical in shape.

This fine species is represented thus far by the single example figured, with its counterpart. It is a very long, narrow fruit, 9.5 cm. in length and only about 1.5 cm. in width. The nucleus or seed proper is large, being 2 cm. in long, and nearly 1 cm. in short, diameter.

The scar where it was attached to its sister fruit is oblique and very long.

I know nothing either living or fossil to which this fruit can be compared.

Locality.—Gulch 1 mile northeast of Belshaw's ranch, Grant County, Oregon. Collected by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., No. 8502).

RULAC CRATÆGIFOLIUM n. sp.

Pl. XVI, fig. 7.

Leaf coriaceous, trifoliolate or very deeply three-lobed, lateral leaflet (or lobe) roughly ovate-lanceolate in shape, irregularly, deeply cut into toothed lobes or large teeth near the apex, wedge-shaped at base, acuminate at apex; middle leaflet (or lobe) much smaller than the lateral ones, narrowly ovate-lanceolate, long, wedge-shaped below, very acuminate at apex, margin coarsely toothed; nervation of leaflets (or lobes) consisting of a strong midrib and several pairs of alternate rather thin secondaries which end in the lobes or teeth; finer nervation not preserved.

This species is represented only by the specimen figured, and this unfortunately is not sufficiently well preserved fully to reveal its character. It is presumably trifoliolate, but may be only deeply three-lobed. The larger leaflet is assumed from its position to be a lateral one, the middle one being much smaller. This lateral leaflet is 5.5 cm. in length, and 2.75 cm. in width between the larger lobes. The central leaflet is 4 cm. long and 1.25 cm. in width. Both are sessile.

Owing to the poor state of preservation it is not possible to fix the position of this leaf with certainty. In most trifoliolate leaves, if the leaflets differ in size, the middle one is usually the larger. In this case the larger leaflet of our specimen is the lateral one, and it is assumed to be lateral because it curves away from the smaller one and has a curved midrib, whereas the smaller one is erect and has a straight midrib.

With the limitations set by the imperfections of the specimen it is perhaps unwise to attempt comparisons between it and described forms, yet a few of these may be suggested. Thus the larger leaflet is not greatly unlike *Cratægus acerifolia* Lesq.,[a] from Florissant, Colorado, which itself is probably the same as a part at least of the leaves described as *Myrica diversifolia* Lesq.,[b] from the same locality. These are all long petioled, showing them to be leaves and not leaflets, whereas ours is sessile, showing that it is probably a leaflet.

[a] Cret. and Tert. Fl., p. 198, Pl. XXXVI, fig. 10.

[b] Idem, p. 146, Pl. XXV, figs. 6-15.

If we assume the larger leaflet to be the central one of a trifoliolate leaf, it certainly suggests one of the specimens described by Lesquereux as *Rhus Hilliæ*,[a] also from Florissant. However, the other specimens classed with this one make it extremely improbable that ours is the same. I have, therefore, assumed that it belongs to Rulac (formerly Negundo), the well-known box elder, but it must remain for future collections to settle the question.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., No. 8533).

Family HIPPOCASTANACEÆ.

ÆSCULUS SIMULATA n. sp.

Pl. XV, figs. 1, 2.

Leaflets rather membranaceous in texture, broadly obovate-lanceolate in shape, somewhat unequal-sided, long, wedge-shaped at base, rather abruptly rounded above to an apparently accuminate apex; margin minutely and regularly serrate throughout except for a short distance just above the base; midrib very thick; secondaries numerous, about 15 pairs, alternate, close, mainly parallel, forking or breaking up into two or three branches near the margin and ending in the teeth, occasionally camptodrome, with fine branches on the outside which enter the teeth; nervilles numerous, thin, mainly percurrent, oblique to the secondaries; finer nervation producing minute irregular areolæ.

This fine species is represented by several examples, two of the best being figured. As all are separate leaflets, it is impossible to determine their arrangement. They are short-petioled if not quite sessile. The smaller of the figured specimens has 6 cm. of its length preserved and was probably between 8 and 9 cm. long when perfect. It is 4 cm. wide. The larger specimen has above 9 cm. of its length preserved and is 6 cm. wide.' The entire length was probably about 15 cm.

This species seems very close, indeed, to both *Æsculus octandra* and *Æ. glabra*, well-known living species of the eastern United States.

Locality.—White hill one-half mile east of original Van Horn's ranch locality. Collected by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., Nos. 8519, 8520).

Family SAPINDACEÆ.

SAPINDUS Merriami n. sp.

Pl. IX, fig. 5.

Coriaceous in texture, leaflets ovate in shape, obtusely wedge-shaped at base, obtuse at apex, alternate on the rachis; margin entire; midrib

[a] Cret. and Tert. Fl., p. 194, Pl. XLI., fig. 14 only.

thin, straight; secondaries few, thin, alternate; finer nervation not preserved.

The single example figured is all that can with certainty be referred to this form. It consists of a portion of the upper part of a rachis with two leaflets, neither of which is the terminal one. The lateral ones are alternate and obtusely ovate in shape.

This species resembles certain of the smaller examples referred to *S. obtusifolius* Lesq.,[a] and may possibly be this, but it is smaller and has a thinner secondary nervation.

Locality.—Bridge Creek, Oregon. Collected for the University of California. Type in Mus. Univ. Cal., No. 2506.

SAPINDUS OBTUSIFOLIUS Lesq.

SAPINDUS OBTUSIFOLIUS Lesq., Tert. Fl., p. 266, Pl. XLIX, figs. 10, 11, 1878; Cret. and Tert. Fl., p. 235, Pl. XLVIII, figs. 5–7, 1883.

A single example that seems to belong to this somewhat variable species. It is more like the examples figured from the Green River group, having the narrow shape, thick midrib, and very short petiole of those.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Merriam's expedition of 1900 (Mus. Univ. Cal., No. 892).

SAPINDUS ANGUSTIFOLIUS? Lesq.

SAPINDUS ANGUSTIFOLIUS Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 15, 1888.

The single example referred by Lesquereux to this species remains unique. I should incline to place it in Salix, yet, as it is obscurely preserved, I have permitted it to remain as above, but have questioned the correctness of the reference.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2598).

SAPINDUS OREGONIANUS n. sp.

Pl. XV, fig. 3.

Leaflet coriaceous in texture, elliptical or elliptical-obovate, very unequal-sided at base, apex destroyed; margin perfectly entire; petiole short, thick; midrib very thick; secondaries thin, about twelve pairs, emerging at a low angle, parallel, camptodrome, each arching and joining the one next above; nervilles very irregular, producing large areas between the secondaries, which are filled by the very fine ultimate nervation.

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[a] Tert. Fl., p. 266, Pl. XLIX, figs. 8–11, 1878.

The only specimen referred to this species lacks the upper portion. It appears to have been about 5 cm. in length and nearly 3 cm. in width, with a petiole 4 mm. long. The nervation is well shown in the figure.

I at first inclined to refer this to *Sapindus obtusifolius* Lesq.,[a] which has been found southeast of Green River station, Wyoming, in beds supposed to be "Washakie" in age, and also in the Fort Union beds of Montana and North Dakota. It has about the same size and shape, although perhaps rather elliptical than ovate. The principal difference is in the secondaries, these being more numerous at a lower angle of divergence and less curved upward. The disposition of the nervilles is much the same in both. However, these two species are close, and possibly a series of specimens would show them to be identical.

Locality.—Mascall beds, Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., No. 8538).

Family RHAMNACEÆ.

RHAMNUS CLEBURNI? Lesq.

RHAMNUS CLEBURNI Lesq., Tert. Fl., p. 280, Pl. LIII, figs. 1–3, 1878.

The collections made by Merriam's expedition contain a single broken specimen that may belong to this species, but it is only the upper portion of the blade, and it is impossible to identify this specimen with certainty in the absence of the basal portion. It seems to be this species, however.

Locality.—Cherry Creek, Cook County, Oregon. Collected by Merriam's expedition in 1900 (Mus. Univ. Cal., No. 180).

RHAMNUS ERIDANI Unger.

RHAMNUS ERIDANI Unger. Newberry, Later Extinct Floras, p. 118, Pl. XLVIII, fig. 7, 1898.

Locality.—Bridge Creek, Grant County, Oregon. Collected by Rev. Thomas Condon (U. S. Nat. Mus., No. 9103).

Family TILIACEÆ.

GREWIA CRENATA (Unger) Heer.

GREWIA CRENATA (Unger) Heer, Fl. Tert. Helv., Vol. III, p. 42, Pl. CIX, figs. 12–21; Pl. CX, figs. 1–11, 1859; Ward, Types of the Laramie Flora, p. 85, Pl. XXXIX, fig. 1, 1887; Newberry, Later Extinct Floras, p. 120, Pl. XLVI, fig. 2; Pl. XLVII, figs. 2, 3, 1898 (1899).

Paliurus colombi Heer. Lesquereux, Proc. U. S. Nat. Mus., Vol. XI, p. 16, 1888.

Grewia crenata was first found in this area at Bridge Creek, and the specimens figured by Newberry, as well as a number of others

[a] Tert. Fl., p. 266, Pl. XLIX, figs. 8–11, 1878.

since obtained, are before me. They not only agree among themselves but quite closely, indeed, with the figures of this species given by Heer. There can be no reasonable doubt as to their identity.

A number of specimens have been found in the Mascall beds at Van Horn's ranch and vicinity that must also be referred to *Grewia crenata*. The single example referred by Lesquereux to *Paliurus colombi* probably belongs here, although it is very much like certain forms of *Populus Zaddachi* from the Auriferous gravels of California. The leaves, three in number, from the Mascall beds are a little narrower than those from Bridge Creek, and are somewhat more deeply cordate or auriculate at base, but the differences are not sufficient to warrant separating them.

Locality.—Bridge Creek, Oregon. Collected by Rev. Thomas Condon (U. S. Nat. Mus., Nos. 7077, 7078, 7079) and Maj. Charles E. Bendire (U. S. Nat. Mus., No. 9532). Mascall beds, Van Horn's ranch and vicinity. Collected by Major Bendire (U. S. Nat. Mus., No. 2542) and by Knowlton and Merriam July, 1901 (U. S. Nat. Mus., Nos. 8990, 8991).

GREWIA AURICULATA Lesq.

GREWIA AURICULATA Lesq., Cret. and Tert. Fl., p. 252, Pl. LV, fig. 1, 1883.

This species appears to rest on the single example figured as the type. None of the recent collections contain it, although there are a number of specimens of *G. crenata*.

The type of *G. auriculata* should be in the University of California, but it can not now be found. If it has been correctly figured it seems to be very different from the other leaves of Grewia found in the same beds, although it may be only an abnormal form of that species.

Locality.—Bridge Creek, Grant County, Oregon. Collected by Rev. Thomas Condon.

Family ARALIACEÆ.

ARALIA DIGITATA Ward.

ARALIA DIGITATA Ward. Lesquereux, Proc. U. S. Nat. Mus., Vol. XI, p. 20, Pl. XI, fig. 4, 1888.

Locality.—Cherry Creek, Crook County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2424).

ARALIA sp. ?

Aralia notata Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 20, 1888.

The collection contains the example referred to *Aralia notata* by Lesquereux and a fragment of the base of another. There is hardly

sufficient data to warrant placing them in this species, and until further material can be obtained it seems best to leave them as above indicated.

Locality.—Cherry Creek, Crook County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., Nos. 2426, 2430).

ARALIA ? sp. Knowlton.

Pl. XVI, fig. 8.

ARALIA ? sp., Knowlton in Merriam, Univ. Cal., Bull. Dept. Geol., Vol. II, No. 9, p. 289, 1901.

A fragment of what appears to be the upper part of a lobe of an Aralia. It has an entire margin and alternate, much curved, rather thin secondaries.

This may be the upper portion of a single leaf like Juglans, but on the slab appears more like Aralia If this latter view be true, its form can only be conjectured.

Locality.—Three miles above Clarnos Ferry. Collected by Merriam's expedition of 1900 (Mus. Univ. Cal., No. 912).

ARALIA sp., Knowlton.

Plate XV, fig. 4.

ARALIA sp., Knowlton in Merriam, Univ. Cal., Bull. Dept. Geol., Vol. II, No. 9, p. 289, 1901.

The fragmentary upper portion of a large leaf, showing portions of three lobes. The lobes are some 5 or 6 cm. in length and about 3 cm. in width. They appear to be without teeth.

It is impossible to tell from this fragment what it is. It may be the upper portion of a moderate sized leaf of *Aralia Whitneyi* Lesq.

Locality.—Three miles above Clarnos Ferry. Collected by Merriam's expedition of 1900 (Mus. Univ. Cal., No. 913).

ARALIA WHITNEYI? Lesq.

ARALIA WHITNEYI Lesq., Foss. Pl. Aurif. Gravel, p. 20, Pl. V, fig. 1, 1878; Proc. U. S. Nat. Mus., Vol. XI, p. 16, 1888.

The early collection from Van Horn's ranch contained a single example that Lesquereux referred with some doubt to this species, and the later collection also contains a single specimen which I assume to belong here. It is a smaller leaf than the figured type, which is itself much smaller than the normal-sized leaves, and naturally has shorter lobes, but it can hardly be anything else.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2429). Smaller specimen obtained by Merriam's expedition in 1900 (Mus. Univ. Cal., No. 845).

Family CORNACEÆ.

CORNUS FEROX? Unger.

CORNUS FEROX Unger. Lesquereux, Proc. U. S. Nat. Mus., Vol. XI, p. 21, 1888.

A single much-broken example is all that was found. Its identification is extremely doubtful, and is permitted to stand simply for the purpose of calling attention to the fact that there is present in these beds a large leaf that, while resembling *Cornus ferox*, is of practically unknown affinity. For purposes of correlation it is obviously of no value.

Locality.—Cherry Creek, Crook County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2452).

Family ERICACEÆ.

ANDROMEDA CRASSA Lesq.

Pl. XVI, fig. 3.

ANDROMEDA CRASSA Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 16, 1888.

This species has not before been figured. It still rests on the type specimen.

Locality.—Van Horn's ranch, South Fork of John Day River, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 8511).

Family EBENACEÆ.

DIOSPYROS ALASKANA Schimper.

DIOSPYROS ALASKANA Schimper, Pal. Vég., Vol. II, p. 949, 1872.
Diospyros lancifolia Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 21, 1888.

Represented by the upper portions of two leaves only; probably correctly identified.

Locality.—Cherry Creek, Crook County, Oregon. Collected by Maj. Charles E. Bendire. (U. S. Nat. Mus., No. 2461.)

DIOSPYROS ELLIPTICA n. sp.

Pl. XVI, fig. 5.

Leaf coriaceous in texture, elliptical in shape, rounded at base to the short petiole, very obtuse at apex; midrib very thick; secondaries four or five pairs, thin, alternate, at an angle of about 45°, camptodrome arching and joining well inside the margin with a fine mesh outside; intermediate secondaries occasional; finer nervation producing an irregular network.

Of this species I have only seen the leaf figured. It is elliptical in outline, very obtuse at apex, and rounded at base. It is 3.25 cm. in length to the petiole, which is less than 3 mm. long and 2 cm. in width. The nervation consists of a very thick midrib and some four or five pairs of alternate thin secondaries which arch and join some distance from the margin.

This species has the nervation of living American species of Diospyros, but is more obtuse at apex than is usual in these leaves.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Knowlton and Merriam, July, 1901, (U. S. Nat. Mus., No. 8556).

Family OLEACEÆ.

Fraxinus integrifolia Newb.

Fraxinus integrifolia Newb., Proc. U. S. Nat. Mus., Vol. V, p. 509. 1883; Later Extinct Floras, p. 128, Pl. XLIX, figs. 1-3, 1898.

This species is represented in all the collections from Bridge Creek by a large number of examples which agree exactly with Newberry's types. When the lower surface of the leaves is exposed the nervation shows clearly, but when the upper surface is the one exposed it is impossible to detect a trace of the nervation. This shows conclusively that the leaves were very thick and coriaceous. The upper surface is also minutely wrinkled, as would be the case with a thick, leathery leaf. From these considerations I am inclined to doubt the correctness of referring them to Fraxinus, but for the present they may be so retained.

Locality.—Bridge Creek, Grant County, Oregon. Collected by Rev. Thomas Condon (U. S. Nat. Mus., Nos. 7062, 7090) and Maj. Charles E. Bendire (U. S. Mus., Nos. 7062, 7090).

Fraxinus denticulata Heer?

Fraxinus denticulata Heer? Newberry, Later Extinct Floras, p. 128, Pl. XLIX, fig. 6, 1898.

More or less doubt still attaches to this form.

Locality.—Bridge Creek, Grant County, Oregon. Collected by Rev. Thomas Condon.

INCERTÆ SEDES.

Phyllites wascoensis Lesq.

Phyllites wascoensis Lesq., Proc. U. S. Nat Mus., Vol. XI, p. 22, Pl. XIV, fig. 3, 1888.

Locality.—Cherry Creek, Crook County, Oregon. Collected by Maj. Charles E. Bendire (U. S. Nat. Mus., No. 2633).

PHYLLITES sp.

Pl. XVII.

The recent material from Cherry Creek contains the single fragment figured, which is just sufficient to show that a leaf of immense size was present in these beds. It is a segment, evidently from near the middle of the blade, showing a width of at least 22 cm. Apparently little or none of the margin is retained.

So little of this leaf is preserved that it is impossible to conjecture as to its affinity.

Locality.—Cherry Creek, Crook County, Oregon. Collected by Knowlton and Merriam, July, 1901.

PHYLLITES OREGONIANUS n. sp.

Pl. XVI, fig. 1.

Phyllites n. sp., Knowlton in Merriam, Univ. Cal., Bull. Dept. Geol., Vol. II, No. 9, p. 303, 1901.

Leaf of firm texture, lanceolate, narrowly wedge-shaped at base, acuminate at apex; margin perfectly entire; midrib very thin; secondaries very thin, about eight pairs, alternate, arising at an acute angle and much curving upward, camptodrome; nervilles few, obscure; finer nervation not preserved.

The example figured is about 6.5 cm. long and about 1.5 cm. wide. Another much-broken example was apparently about the same length, but was nearly 3 cm. broad. It has the same kind of secondaries and has the nervilles better preserved, these being usually broken.

I am uncertain as to the affinities of this little leaf, although in some respects it suggests Cornus.

Locality.—Three and one-half miles south of Lone Rock, Gilliam County, Oregon. Collected by Merriam's expedition of 1900 (Mus. Univ. Cal., No. 1334).

PHYLLITES BIFURCIES n. sp.

Pl. XVI, fig. 2.

Leaf coriaceous, ovate or ovate-elliptical in shape, abruptly rounded at base (apex destroyed), with a single triangular-lanceolate, acuminate basal lobe; margin otherwise coarsely toothed, the teeth sharp, pointing upward; petiole short, strong; midrib very strong below, becoming very thin above; secondaries numerous, thin, somewhat irregular, ending in the lobe and marginal teeth; finer nervation not retained.

The curious leaf figured is apparently all that is represented of this form. It was apparently between 7 and 8 cm. in length, exclusive of the petiole, nearly 1 cm. long, and is 4.5 cm. broad between the tip of

the long lobe and the opposite of the blade. The major part of the blade is only 3 cm. broad. The single basal lobe is 2 cm. long.

This leaf presents a very curious appearance with the long, sharp-pointed lobe on one side, and it is quite possible that it is an abnormal example perhaps of some well-known form. If it is the normal form, it is certainly one that will be readily recognizable in future. Its affinity is obviously in doubt. If it were not for the presence of the single basal lobe it might perhaps be referred to Betula, but I do not know any species, either living or fossil, with which it can be satisfactorily compared.

Locality.—White hill one-half mile east of original Van Horn's ranch locality, 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., No. 8537).

PHYLLITES INEXPECTANS n. sp.

Pl. XVI, fig. 6.

Leaf evidently coriaceous, obovate-lanceolate in shape, narrowed below, obtuse and rounded at apex; margin perfectly entire; petiole long, very strong for the size of the leaf; midrib also very strong; other nervation obscure.

This form is represented by the example figured. It is narrowly obovate-lanceolate in outline, 3.25 cm. long and 9 mm. wide at the broadest part, which is near the upper extremity. The petiole is 6 mm. long. Unfortunately nothing of the nervation except the thick midrib is preserved.

This leaf resembles quite closely certain of the leaves referred to *Quercus convexa* Lesq.,[a] from the Auriferous gravels of California. These leaves are uniformly thick and coriaceous, yet the nervation shows distinctly in all cases. Our leaf is apparently no thicker, yet has no trace of the nervation beyond the midrib. The petiole in *Q. convexa* is uniformly short, whereas in the leaf under discussion it is several times longer, being about one-fourth the length of the blade.

On the whole, this leaf is perhaps closest to *Phyllites obscurus* Knowlton,[b] from the Payette formation of Idaho. This latter species, however, is elliptical-lanceolate or slightly ovate-lanceolate, while ours is distinctly obovate-lanceolate. The petiole and midrib are similar, and both also lack details of nervation. Perhaps a larger series might show them to grade together.

Locality.—Van Horn's ranch, about 12 miles west of Mount Vernon, Grant County, Oregon. Collected by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., No. 8547).

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[a] Foss. Pl. Aurif. Gravel, p. 4, Pl. I, figs. 13-17; Cret. and Tert. Fl., p. 265, Pl. XLV, figs. 5, 6.
[b] Eighteenth Ann. Rept. U. S. Geol. Surv., Pt. III, p. 735, Pl. XCIX, figs. 10, 11, 1898.

PHYLLITES PERSONATUS n. sp.

Plate XVI, fig. 4.

Leaf evidently thick and leathery in texture, narrowly obovate-lanceolate in shape, long, wedge-shaped at base, acuminate at apex; margin perfectly entire; midrib very thin, almost disappearing above; secondaries three or four pairs, very thin and obscure, the two lower pairs close together near the base of the blade, at an acute angle, passing up for a long distance, camptodrome and apparently joining the one next above; nervilles obscure, apparently arising at an acute angle from the secondaries and soon lost; finer nervation not satisfactorily discernible.

The single specimen figured is all I have seen of this form. It is a small leaf, about 4.5 cm. long and 1.5 cm. wide, being slightly obovate-lanceolate in shape. From the faint impression of the nervation as well as the wrinkled appearance it is inferred that the leaf was of thick and leathery texture.

Locality.—Cherry Creek, Crook County, Oregon. Collected by Knowlton and Merriam, July, 1901 (U. S. Nat. Mus., No. 8554).

SPECIES EXCLUDED FROM THIS WORK.

A number of species that are not now recognized have, at one time or another, been referred to the various beds within the John Day Basin. The reasons for excluding each are set forth in the following list:

Alnus corrallina Lesq., Cret. and Tert. Fl., p. 243, Pl. LI, figs. 1–3, 1883. The original of fig. 1 is said by Lesquereux to be from "John Day Valley, Oregon." This specimen is No. 1944 of the paleontological collection of the University of California, and is from south of Mount Diablo, California, agreeing with others from the same place, and being so marked on the back.

Betula elliptica Saporta. Lesq., Cret. and Tert. Fl., p. 242, Pl. LI, fig. 6, 1883. Said by Lesquereux to be from "John Day Valley, Oregon." It is No. 1760 of the paleontological collection of the University of California, and is from south of Mount Diablo, California.

Betula parce-dentata Lesq., Cret. and Tert. Fl., p. 242, Pl. L, fig. 12, 1883. Said by Lesquereux to be from "John Day Valley, Oregon." It is from south of Mount Diablo, California, and is No. 1955 of the paleontological collection of the University of California.

Berchemia multinervis (Al. Br.) Heer. Lesquereux, Proc. U. S. Nat. Mus., Vol. XI, p. 16, 1888. Not found in the collection of the United States National Museum. Omitted for lack of evidence.

Populus glandulifera Heer. Lesquereux, Proc. U. S. Nat. Mus., Vol. XI, p. 18, 1888. A single broken example that it is impossible to identify.

Quercus lonchitis Unger. Lesquereux, Proc. U. S. Nat. Mus., Vol. XI, p. 22, 1888. Much broken and impossible of identification.

Quercus fraxinifolia Lesq., op. cit., p. 22. Discarded for same reasons as the last.

Quercus Olafseni Heer. Lesquereux, op. cit., p. 22. Rejected for the same reason as the last two.

Juglans Leconteana Lesq., op. cit., p. 22. Same as the last.

Juglans denticulata Heer. Lesquereux, op. cit., p. 22. Could not be found in the collection of the United States National Museum.

Pteris elegans Newb., Proc. U. S. Nat. Mus., Vol. V, p. 503, 1883. Not recognized by its author in his Later Extinct Floras and specimens now lost, so far as known.

LIST OF SYNONYMS.

As a considerable number of changes in the names and disposition of species have been made in the present paper, the following list of changes is presented for the convenience of users of previous literature:

Acer, fruit of, Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 15 = *Acer oregonianum*, n. sp.

Acer trilobatum productum (Al. Br.) Heer. Lesq., Cret. and Tert. Fl., Pl. LIX, figs. 1, 2, 4 = *Acer Bendirei* Lesq.; fig. 3 = *Platanus dissecta* Lesq.

Aralia pungens Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 16 = *Artocarpus californica?* Knowlton.

Carpinus pyramidalis (Göpp.) Heer. Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 18 = *Carpinus grandis?* Unger.

Carpinus, involucre of = *Betula heteromorpha*.

Carya elænoides (Ung.) Heer. Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 18 = *Hicoria elænoides* (Ung.) Knowlton.

Cassia phaseolites? Unger. Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 16 = *Salix Engelhardti* Lesq.

Castanea atavia Unger. Lesq., Cret. and Tert. Fl., p. 247, Pl. LII, fig. 2 = *Quercus horniana* Lesq.

Diospyros lancifolia Lesq. = *D. alaskana* Schimp.

Equisetum Hornii Lesq. = *E. oregonense* Newb.

Fagus castaneæfolia Unger. Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 18 = *Fagus?* sp.

Ficus? Condoni Newb. = *Platanus Condoni* (Newb.) Knowlton.

Fraxinus affinis Newb. = *Quercus affinis* (Newb.) Knowlton.

Ilex longifolia Heer. Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 21 = *Juglans? Bendirei* Knowlton.

Juglans hesperia Knowlton = *J. oregoniana* Lesq.

Lastrea Knightiana Newb. = *Lastrea Fischeri* Heer.

Liquidambar europæum Al. Br. Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 14 = *L. europæum patulum*, n. var.

Lygodium neuropteroides Lesq. = *L. Kaulfusii* Heer.

Marsilea Bendirei Ward = *Hydrangea Bendirei* (Ward) Knowlton.

Myrica diversifolia Lesq., Cret. and Tert. Fl., Pl. L., fig. 10 = *Cratægus flavescens* Newb.

Myrica Lessigii? Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 16 = *Artocarpus californica?* Knowlton.

Paliurus colombi Heer. Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 16 = *Grewia crenata* (Unger.) Heer.

Platanus Raynoldsii Newb. Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 19 = *Platanus* sp.

Populus monodon Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 21 = *Magnolia Culveri* Knowlton.

Populus polymorpha Newb., in part = *Betula heterodonta* Knowlton, *Quercus pseudoalnus* Ett., and *Quercus oregoniana* Knowlton.

Porana Bendirei (Ward) Lesq. = *Hydrangea Bendirei* (Ward) Knowlton.

Pteris pinnæformis Heer. = *P. pseudo-pinnæformis* Lesq.

Pteris subsimplex Lesq. = *Asplenium subsimplex* (Lesq.) Knowlton.

Quercus Breweri Lesq., Cret. and Tert. Fl., Pl. LIV, fig. 9 = *Q. affinis* (Newb.) Knowlton.

Quercus furcinervis (Rossm.) Unger. Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 22 = *Q. furcinervis americana* Knowlton.

Quercus pseudo-lyrata acutiloba Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 17 = *Q. pseudo-lyrata* Lesq.

Quercus pseudo-lyrata angustiloba Lesq., op. cit., p. 17 = *Q. Merriami* Knowlton

Quercus pseudo-lyrata brevifolia Lesq., op. cit., p. 18 = *Q. pseudo-lyrata* Lesq.

Quercus pseudo-lyrata latifolia Lesq., op. cit., p. 18 = *Q. pseudo-lyrata* Lesq.

Quercus pseudo-lyrata obtusiloba Lesq., op. cit., p. 18 = *Q. pseudo-lyrata* Lesq.

Rhus Bendirei Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 15 (the small leaflet described) = *Juglans oregoniana* Lesq.

Sequoia Nordenskiöldii Heer. Lesq., Proc. U. S. Nat. Mus., Vol. XI, p. 19 = *S. angustifolia* Lesq.

Taxodium distichum miocenum Heer. Newberry, Later Extinct Floras, Pl. XLVII, fig. 6 = *Sequoia Langsdorfii* (Brgt.) Heer.

Ulmus pseudo-americana Lesq. = *U. speciosa* Newb.

Ulmus speciosa Newb., Later Extinct Floras, Pl. XLV, figs. 5, 8 = *Ulmus Newberryi* Knowlton.

DISCUSSION OF THE FLORA

STATISTICAL VIEW.

The fossil flora of the John Day Basin, as set forth in the preceding pages, is seen to be a rich and interesting one. Although the present enumeration comprises all that is now known regarding the fossil plants, it is probably still far from complete, as every collection contains a good proportion of new forms. But as it is in a measure a type locality, it has seemed proper to present a summary of existing knowledge, in order that the information may be made available for use in contiguous and obviously related areas.

The following table has been prepared for the purpose of bringing out the local distribution and the stratigraphic relationships of the plants:

Table showing distribution of species in the John Day Basin, Oregon.

Page of this work.	Species.	Currant Creek.	Cherry Creek.	Bridge Creek.	1½ miles E. of Clarnos Ferry.	3 miles above Clarnos Ferry.	½ milo NE. of Fossil.	3¼ miles S. of Lone Rock.	Van Horn's ranch and vicinity.	Officer's ranch.
		1	2	3	4	5	6	7	8	9
21	Lygodium Kaulfusii Heer	....	×	....	....	....	....	....	....	....
21	Asplenium subsimplex (Lesq.) Kn.	....	×	....	....	....	....	....	....	....
22	Pteris pseudo-pinnæformis? Lesq.	×	....	....	....	....	....	....	....	....
22	Lastrea Fischeri? Heer	×	....	....	....	....	....	....	....	....
22	Equisetum oregonense Newb.	×	×	....	....	....	....	....	....	....
23	sp	....	....	....	....	....	....	....	×	....
23	Ginkgo sp	....	....	....	....	....	....	....	×	....
23	Sequoia Heerii Lesq	....	....	×	....	....	....	....	....	....
24	angustifolia Lesq	....	....	....	....	....	....	....	×	....

Table showing distribution of species in the John Day Basin, Oregon—Continued.

Page of this work.	Species.	Currant Creek.	Cherry Creek.	Bridge Creek.	1½ miles E. of Clarnos Ferry.	3 miles above Clarnos Ferry.	½ mile NE. of Fossil.	3½ miles S. of Lone Rock.	Van Horn's ranch and vicinity.	Officer's ranch.
		1	2	3	4	5	6	7	8	9
25	Sequoia Langsdorfii (Brgt.) Heer	....	....	×	×	....	×	×	×	....
26	sp	....	....	....	....	....	....	....	×	....
26	Thuites sp	....	....	....	....	....	....	....	×	....
26	Glyptostrobus Ungeri Heer	....	....	....	....	....	....	....	×	....
27	Taxodium dist. miocenum Heer	....	....	....	....	....	....	....	×	....
27	male aments of	....	....	....	....	....	....	....	×	....
27	Phragmites œningensis Al. Br	....	....	....	....	....	....	....	×	....
28	Cyperacites sp	....	....	....	....	....	....	....	×	....
28	Smilax Wardii Lesq	....	....	....	....	....	....	....	×	....
28	Monocotyledonous plant	....	....	×	....	....	....	....	....	....
29	Populus Lindgreni Kn	....	....	....	....	....	....	....	×	....
29	Salix Schimperi Lesq	....	×	....	....	....	....	....	....	....
29	Engelhardti Lesq	....	....	....	....	....	....	....	×	....
30	Ræana? Heer	....	....	....	....	....	....	....	×	....
30	varians Göppert	....	....	....	....	....	....	....	×	....
30	angusta Al. Br	....	....	....	....	....	....	....	×	....
30	amygdalæfolia Lesq	....	....	....	....	....	....	....	×	....
31	pseudo-argentea n. sp	....	....	....	....	....	....	....	×	....
31	dayana n. sp	....	....	....	....	....	....	....	×	....
31	perplexa n. sp	....	....	....	....	....	....	....	×	....
32	mixta n. sp	....	....	....	....	....	....	....	×	....
32	sp.? Knowlton	....	....	....	....	....	....	×	....	....
33	Myrica oregoniana n. sp	....	....	....	....	....	....	....	×	....
33	? personata n. sp	....	....	....	....	....	×	....	....	....
34	Juglans rugosa Lesq	....	×	....	....	....	....	....	....	....
34	? Bendirei n. sp	....	×	....	....	....	....	....	....	....
34	Schimperi? Lesq	....	....	×	....	....	....	....	....	....
35	acuminata? Al. Br	....	....	×	....	....	....	....	....	....
35	cryptata n. sp	....	....	×	....	....	....	....	....	....
36	crassifolia n. sp	....	....	....	....	....	....	×	....	....
36	oregoniana Lesq	....	....	....	....	....	....	....	×	....
37	Hicoria? oregoniana n. sp	....	×	....	....	....	....	....	....	....
38	sp?	....	....	×	....	....	....	....	....	....
38	elænoides (Ung.) Kn	....	....	....	....	....	....	....	×	....
38	Carpinus betuloides Unger	....	....	×	....	....	....	....	....	....
38	grandis? Unger	....	....	....	....	....	....	....	×	....
38	Corylus MacQuarrii (Forbes) Heer	....	....	×	....	....	....	....	....	....
39	Betula heteromorpha n. sp	....	....	×	....	....	....	....	....	....
40	heterodonta Newb	....	....	×	....	....	....	....	....	....
40	Bendirei n. sp	....	....	×	....	....	....	....	....	....
41	angustifolia Newb	....	....	×	....	....	....	....	....	....
41	? dayana n. sp	....	....	....	....	....	....	....	×	....
42	Alnus carpinoides Lesq	....	....	×	×	....	×	....	....	....
42	serrulata fossilis Newb	....	....	×	....	....	....	....	....	....
42	macrodonta n. sp	....	....	×	....	....	....	....	....	....
42	sp.? fruit of, Newb	....	....	×	....	....	....	....	....	....
43	Kefersteinii? (Göpp.) Unger	....	....	....	....	....	....	....	×	....
43	Fagus? sp	....	....	....	....	....	....	....	×	....
43	Quercus furcinervis Americana Kn	....	×	....	....	....	....	....	....	....
43	? sp	....	×	....	....	....	....	....	....	....

Table showing distribution of species in the John Day Basin, Oregon—Continued.

Page of this work.	Species.	Currant Creek.	Cherry Creek.	Bridge Creek.	1¼ miles E. of Clarnos Ferry.	3 miles above Clarnos Ferry.	½ mile NE. of Fossil.	3½ miles S. of Lone Rock.	Van Horn's ranch and vicinity.	Officer's ranch.
		1	2	3	4	5	6	7	8	9
44	Quercus paucidentata Newb			×						
44	drymeja Unger			×						
44	simplex Newb			×						×
45	affinis (Newb.) Kn			×						
45	consimilis Newb			×						×
46	Breweri Lesq			×						
46	pseudo-alnus Ett			×						
47	oregoniana n. sp			×						
48	pseudo-lyrata Lesq									
49	Merriami n. sp								×	
50	duriuscula n. sp								×	
51	ursina n. sp								×	
51	dayana n. sp								×	
52	horniana Lesq								×	
53	? sp. Knowlton								×	
53	Ulmus speciosa Newb			×					×	
54	Newberryi n. sp			×						
55	plurinervia Unger								×	
55	californica? Lesq								×	
55	Planera Ungeri Ett								×	
55	Ficus tenuinervis Lesq		×							
56	planicostata? Lesq			×						
56	? oregoniana Lesq								×	
56	Artocarpus californica? Kn								×	
56	Berberis simplex Newb			×						
57	gigantea n. sp								×	
58	Magnolia lanceolata Lesq		×?						×	
58	Culveri Kn		×							
58	Inglefieldi Heer								×	
58	Laurus oregoniana n. sp								×	
59	Cinnamomum Dilleri Kn		×							
59	Bendirei n. sp			×						
60	Hydrangea Bendirei (Ward) Kn								×	
62	Liquidambar europæum Al. Br			×						
62	europæum n. var								×	
62	protensum? Unger								×	
63	pachyphyllum n. sp								×	
63	sp.?								×	
64	Platanus aspera Newb			×						
64	Condoni (Newb.) Kn			×						×
65	nobilis? Newb								×	
65	aceroides? (Göpp.) Heer								×	
66	sp								×	
66	Cratægus flavescens Newb			×						×
66	imparilis n. sp								×	
67	Prunus ? Merriami n. sp								×	
68	tufacea n. sp								×	
69	Acacia oregoniana Lesq								×	
69	Cassia ? sp. Newb			×						
69	Ailanthus ovata Lesq			×						

Table showing distribution of species in the John Day Basin, Oregon—Continued.

Page of this work.	Species.	Currant Creek.	Cherry Creek.	Bridge Creek.	1¼ miles E. of Clarnos Ferry.	3 miles above Clarnos Ferry.	¼ mile NE. of Fossil.	3½ miles S. of Lone Rock.	Van Horn's ranch and vicinity.	Officer's ranch.
		1	2	3	4	5	6	7	8	9
70	Rhus Bendirei Lesq								×	
70	? sp. Lesq								×	
71	Celastrus dignatus n. sp								×	
71	confluens n. sp								×	
72	Acer Osmonti n. sp			×						
73	sp				×					
73	Bendirei Lesq								×	
74	dimorphum Lesq								×	
74	Merriami n. sp								×	
75	branches of								×	
75	oregonianum n. sp								×	
76	medianum n. sp								×	
76	minor n. sp								×	
76	gigas n. sp								×	
77	Rulac crataegifolium n. sp								×	
78	Æsculus simulata n. sp								×	
78	Sapindus Merriami n. sp			×						
79	obtusifolius Lesq								×	
79	angustifolius ? Lesq								×	
79	oregonianus n. sp								×	
80	Rhamnus Cleburni? Lesq		×							
80	Eridani Unger			×						
80	Grewia crenata (Ung.) Heer			×					×	
81	auriculata Lesq			×						
81	Aralia digitata Ward		×							
81	sp.?		×							
82	? sp. Knowlton					×				
82	sp. Knowlton					×				
82	Whitneyi ? Lesq									
83	Cornus ferox ? Unger		×							
83	Andromeda crassa Lesq								×	
83	Diospyros alaskana Schimp		×							
83	elliptica n. sp								×	
84	Fraxinus integrifolia Newb			×						
84	denticulata ? Heer			×						
84	Phyllites wascoensis Lesq		×							
85	sp		×							
85	oregonianus n. sp							×		
85	bifurcies n. sp								×	
86	inexpectans n. sp								×	
87	personatus n. sp								×	

An examination of the table shows that the flora as at present understood comprises 150 forms, of which number 44 species and 1 variety are described as new to science. Of the remaining number 24 are forms not specifically named, thus leaving 81 species, or about 53 per cent, of previously known species.

The following table shows at a glance the number of forms found at each of the localities:

Table showing the number of forms at each locality.

Currant Creek	3
Cherry Creek	20
Bridge Creek	46
One and one-half miles east of Clarnos Ferry	3
Three miles above Clarnos Ferry	2
One and one-half miles northeast of Fossil	3
Three and one-half miles south of Lone Rock	4
Van Horn's ranch and vicinity	80
Officer's ranch	3

From this it appears that three localities—namely, Cherry Creek, Bridge Creek, and Van Horn's ranch and vicinity—afford over 90 per cent of the entire flora.

BIOLOGICAL CONSIDERATIONS.

As already pointed out, the present woody flora of the John Day Basin is inconsiderable, consisting of pines along the higher ridges, occasional junipers along the lower ridges, and a scant fringe of cottonwoods and willows along the streams. At best not more than three families are represented. The fossil flora, on the other hand, is a relatively rich one, and shows especially a great variety of woody plants. Following is a complete list of families represented:

Schizæaceæ.	Ulmaceæ.	Celastraceæ.
Polypodiaceæ.	Moraceæ.	Aceraceæ.
Equisetaceæ.	Berberidaceæ.	Hippocastanaceæ.
Ginkgoaceæ.	Magnoliaceæ.	Sapindaceæ.
Pinaceæ.	Lauraceæ.	Rhamnaceæ.
Gramineæ.	Hydrangeaceæ.	Tiliaceæ.
Cyperaceæ.	Hamamelidaceæ.	Araliaceæ.
Smilaceæ.	Platanaceæ.	Cornaceæ.
Salicaceæ.	Rosaceæ.	Ericaceæ.
Myricaceæ.	Mimosaceæ.	Ebenaceæ.
Juglandaceæ.	Cæsalpinaceæ?	Oleaceæ.
Betulaceæ.	Simarubaceæ.	
Fagaceæ.	Anacardiaceæ.	

The ferns, judging from the remains, must have played a very inconspicuous rôle in the Tertiary flora of this region. Two families and only four species are represented, and these are confined to a single horizon. They are also few in individuals, Lygodium being the most abundant.

Associated in the same beds with the ferns are a large number of individuals of an Equisetum, all of which have been referred to a single species (*E. oregonense* Newb.). The confused character of the matrix gives no indication of the height to which this species grew, but it must have been conspicuous, for it is not uncommon to find

stems nearly 3 cm. in diameter; the majority of them, however, are considerably smaller. The only other Equisetum is a small, more or less doubtful fragment from the Mascall beds, not enough of it being preserved to convey a satisfactory idea of its size and appearance.

Ginkgo is represented in the highest plant-bearing beds (Mascall) by a few fragments that are so poorly preserved as to give very little idea of it beyond the fact that it appears to have been larger leaved than the ordinary leaves of the living species.

The Pinaceæ, although represented by four genera and six or seven species, could hardly have been a very conspicuous element in the Tertiary flora of the basin. The most abundant species was the widely distributed *Sequoia Langsdorfii*, which occurs at five of the localities. Associated in the beds at Bridge Creek are a few cones of what Lesquereux has called *Sequoia Heerii*, that may possibly belong to what has been identified as *S. Langsdorfii*, but if this be so, the latter identification can hardly be correct.

The remaining conifers are all confined to the Mascall beds. Of these, *Sequoia angustifolia*, *Taxodium distichum miocenum*, and what has been called *Glyptostrobus Ungeri* are the most abundant. Taxodium is also represented by what, with little question, are male aments. It is more than probable that they belong to *T. distichum miocenum*. *Thuites* is represented by a mere fragment. The Gramineæ and Cyperaceæ are each represented by a single form, both of which are more or less doubtful.

To the Smilaceæ is referred the single species *Smilax Wardii*. It is very rare, as only one leaf has ever been discovered.

We come now to the deciduous-leaved types of vegetation, and it requires but a glance at the list of families to show that they predominate to a marked degree. They are represented not only by numerous genera and species, but in the case of some forms by a great wealth of individuals. The deposits at Bridge Creek, many feet in thickness, are filled with thousands of leaves of Betula, Alnus, Quercus, etc., and the Mascall beds at Van Horn's ranch contain great numbers of leaves of oaks, willows, and maples. We therefore seem warranted in concluding that the Tertiary flora of the basin was distinctly a hard-wood flora, not unlike in general appearance that which characterizes much of the area east of the Mississippi River at the present time. This fact is still further emphasized by the evident close relationship between certain of the species found fossil in the John Day Basin and those now living in the Eastern States. This will be brought out more fully under the discussion of each family.

The Salicaceæ are represented by both Populus and Salix, but of the former genus only one species (*P. Lindgreni*), represented by a single leaf, has thus far been found. This species was first characterized from the Payette formation of Boise County, Idaho. As I have

already said, "Among living species this appears to approach most closely to *P. balsamifera candicans.* It differs in being much more obtuse, in having a more marked serrate border, and in the stronger nervation. The relationship is, however, quite marked, the two leaves being of the same type, but with strong specific differences."[a]

The genus Salix is represented by eleven forms, all but one of which (*S. Schimperi*) are confined to the upper beds. Several of the species included are represented by single and often more or less doubtful specimens, while others are represented by numerous individuals. Thus *S. pseudo-argentea* is very abundant. It closely resembles the living *S. argentea*, whence its name. *Salix perplexa*, to which is referred a dozen or more specimens, is very similar in general appearance to certain forms of *S. Bebbiana*, a species now widely distributed throughout the Rocky Mountain region. The Myricaceæ are represented by two species, both of which are described as new. Of these, *M. oregoniana* is very closely related to *M. callicomæfolia* Lesq., a species very abundant at Elko station, Nevada, and Florissant, Colorado. The other species, *Myrica? personata*, is wholly unlike anything previously described from the John Day region, and may not belong to this genus.

The Juglandaceæ are richly represented, both Juglans and Hicoria being present, the former with eight forms and the latter with three. The species are rather widely distributed, occurring in the older, middle, and younger plant-bearing beds of the region. Perhaps the most interesting form is Lesquereux's *Juglans oregoniana*, which has long been supposed to have come from the Auriferous gravels of California, but which is now known to have come from the Mascall beds at Van Horn's ranch. Quite a number of additional specimens have been found recently, and, with the exception of being slightly smaller, they agree well with the type form. One of the specimens described by Lesquereux as *Rhus Bendirei* has been referred to this, as also my *J. hesperia*, from the Payette formation of Idaho.

Judging from the remains, Hicoria was rather rare, for only a few specimens have been found.

The family Betulaceæ, so far at least as regards individual leaves, is the dominant family of the flora. It is represented by Carpinus, Corylus, Betula, and Alnus, each, except Corylus, with several well-marked species.

The Clarno formation, or the beds at Bridge Creek and allied localities, seems to have witnessed the culmination of the Betulaceæ in the region, for, with the exception of two or three doubtful forms, all the species are confined to it.

Carpinus is represented by numerous leaves, which are referred to *C. betuloides* at Bridge Creek, while two more or less questionable

[a] Eighteenth Ann. Rept. U. S. Geol. Survey, Pt. III, p. 725.

leaves from the Mascall beds are referred to the well-known Miocene *C. grandis*.

Out of the vast number of leaves from Bridge Creek only two have thus far been found which clearly belong to *Corylus MacQuarrii*, and these are not to be distinguished from leaves of this species figured by Heer from Alaska. There can be no doubt as to the correctness of this identification.

Betula, as already pointed out, is the most abundantly represented of any genus in the flora. *B. heteromorpha* and *B. heterodonta* are by far the most abundant species. The first mentioned was in part described by Newberry, under the name of *Populus polymorpha*, from the resemblance to certain of the leaves of the living *P. alba*, but with the great number of individuals at my disposal I can not believe that they should be referred to Populus, although they do somewhat resemble *P. alba*. Hardly to be separated from this is Newberry's *B. heterodonta*, but in general it has much larger leaves, with coarser-toothed margins, and a more markedly inequilateral base. Many of the leaves of both species show evidence of having been attacked by fungi, producing spots and punctures so characteristic of numerous spot-producing fungi. As none of the essential features of these fungi are preserved, no attempt has been made to describe them.

Under the name of *Betula Bendirei* I have ventured to describe a single leaf that, while evidently allied to *B. heteromorpha*, differs in being nearly circular in shape, with an equal base and regularly spaced secondaries.

Almost equally abundant was the species of Alnus described by Lesquereux as *A. carpinoides*. It is contained in all the collections from Bridge Creek, and has also been detected at several other localities within the basin. From a fragment of a single large leaf I have characterized a new species under the name of *A. macrodonta*. It is broadly ovate, with abruptly truncate and heart-shaped base and coarsely dentate margin.

To the Fagaceæ are referred a single very doubtful leaf of Fagus and no less than 17 species or forms of Quercus. The oaks, although not quite so abundant in individuals as certain of the species of Betula, Alnus, etc., above mentioned, are much more abundant in species and in a few cases are nearly as numerous in individuals. The oaks are divided sharply into two groups corresponding to the horizons in which they occur. Thus 8 species are confined to the beds at Bridge Creek and 7 species to the Mascall beds at Van Horn's ranch and vicinity, and very few from either locality have been found beyond the confines of the John Day Basin.

The oaks from Bridge Creek are small, nonlobed forms, with entire or serrate margins. They are also in the main thick, coriaceous-leaved

species, evidently evergreen, and quite like the *Q. virens* type. Those from Van Horn's ranch, on the other hand, are all or nearly all lobed forms, some of them being very profoundly lobed. They are evidently thinner in texture than the Bridge Creek species.

The most abundant form in the Mascall beds is *Q. pseudo-lyrata* of Lesquereux. It is present in abundance in all collections and is hardly to be distinguished from the living *Q. lyrata.* It was divided up by Lesquereux into 5 varieties, but an examination of more than 100 examples convinces me that, with one exception, no satisfactory line can be drawn between them, and they have been reduced to the typical form. The exception above noted is that of Lesquereux's *Q. pseudo-lyrata angustiloba.* After examining more than 25 more or less perfect examples, it became clear that this was entitled to specific rank, and it has been called *Q. Merriami*, the varietal name *angustiloba* being preoccupied by A. Braun's *Q. angustiloba.* It is a very narrowly lanceolate form, quite suggestive of certain leaves of *Q. heterophylla*, the so-called Bartram oak.

A small but very perfectly preserved leaf from the same beds has been called *Q. duriuscula.* This specimen is very close indeed to *Q. minor* (Marsh.) Sargent, the well-known post or iron oak of the Eastern United States.

Another distinctly modern type, represented by several examples, is *Q. ursina*, which is undoubtedly related to *Q. nana* (Marsh.) Sargent, the bear or scrub oak of the Eastern States.

The only entire-leaved oak in the Mascall beds is *Q. dayana*, a very small-leaved species of the *virens* type. It resembles various species, such, for example, as *Q. simplex* Newb., *Q. convexa* Lesq., and *Q. simulata* Knowlton, but appears to differ from them all.

The family Ulmaceæ is represented by four species of Ulmus, evenly divided between Bridge Creek and Van Horn's ranch, and a single one of Planera. Of the two from Bridge Creek, *U. speciosa* Newb., is the largest and finest, being from 10 to 13 cm. in length. It is very suggestive of the living *U. americana*, and was called *U. pseudo-americana* by Lesquereux, but his name is antedated by that of Newberry. The other species, which I have called *U. Newberryi*, has a much smaller and narrower leaf, ranging from 6 to 10 cm. in length, and less than 3 cm. in width. It was referred to *U. speciosa* by Newberry, but seems distinct. Associated with these leaves, but especially with *U. speciosa*, are a number of very perfect examples of the winged fruits. They were placed with *speciosa* by Newberry.

The two species from the Mascall beds are *U. plurinervia* Unger, represented by a single leaf, and *U. californica* Lesq., to which several small leaves are doubtfully referred. It is clear that elms were not abundant in these beds.

Planera (*P. Ungeri* Ett.) is also represented by a single example.

The Moraceæ were not abundant, being represented by three species of Ficus and one of Artocarpus. The figs are all small leaves, and are represented by few specimens, and they evidently played an unimportant part in this flora. Artocarpus is unfortunately represented by only two or three fragments, which were referred by Lesquereux to *Aralia pungens* Lesq. and *Myrica* (*Aralia*) *Lessigii* Lesq. As nearly as can be made out, they are the same as my *A. californica* from the Auriferous gravels of California.

The Berberidaceæ are represented by the very distinct and still unique *Berberis simplex* of Newberry. It is undoubtedly closely related to the living *B. aquifolia*, which is so abundant in the region.

The Magnoliaceæ are represented by three species, two of which (*M. Culveri* and *M. lanceolata*) are found in the lowest beds of the region, and one (*M. Inglefieldi*) in the Mascall beds.

The Lauraceæ are represented by three species—one of Laurus, in the Mascall beds, and two of Cinnamomum, one of which (*C. Dilleri* Kn.) is found at Cherry Creek and the other (*C. Bendirei*) in the Bridge Creek beds.

After much consideration it has seemed probable that the family Hydrangeaceæ is represented by the curious sterile flowers which were first called *Marsilea Bendirei* by Ward and transferred to Porana by Lesquereux. The evidence on which it is changed to Hydrangea is fully set forth in the discussion of this species (ante, p. 60).

Liquidambar, representing the Hamamelidaceæ, was evidently an important group in this flora. Five forms have been detected, several of which are represented by a considerable number of specimens. They all come from the middle and upper plant-bearing beds of the region. The large leaves from Bridge Creek are referred to *L. europæum*, although they approach quite closely in certain specimens to *L. californicum* of Lesquereux. Under the name of *L. europæum patulum* I have characterized a form from the Mascall beds with very broad three-lobed leaves. The identification of Unger's *L. protensum* by Lesquereux is open to doubt. It rests upon a single broken example, and may belong to *Acer dimorphum* Lesq. A very peculiar thick-leaved form has been named *L. pachyphyllum*. It is wholly unlike any of the other forms found in the region.

The Platanaceæ formed an important family, represented by five forms and a large number of examples. Of these *P. aspera* Newb., is peculiar to the Bridge Creek beds, being a medium-sized species with sharp upward-pointing lobes. The largest and most abundant form is *P. Condoni*, originally described by Newberry as a questionable Ficus. This is undoubtedly very closely allied to Ward's *P. basilobata*, if, indeed, it is not actually identical with that species. The main difference lies in the basal lobes. In *P. basilobata* these are several times the size of those in *P. Condoni*, and appear to be always deeply lobed,

whereas they are entire in the latter. Assuming that the evolutional tendency is to get rid of these large stipular organs, as suggested in the living *P. occidentalis*, the Bridge Creek form would represent a more recent and highly developed stage than *P. basilobata*, a supposition borne out by the relative ages of the beds in which they are found.

Another interesting form, unfortunately represented by only a single example, was identified by Lesquereux as *P. nobilis?* Newb. It is a leaf more than 25 cm. long and 23 cm. broad, with a petiole 8 cm. long and some 7 mm. in thickness. The margin is not well preserved. This may well be the *P. nobilis* of Newberry, but additional material will be necessary to definitely establish the fact. The well-known *P. aceroides* of Europe and this country was also determined by Lesquereux from the Mascall beds, but it rests on two examples, neither of which agrees entirely with the ordinary figures of this species. Additional material is needed to settle the status of this species also.

The Rosaceæ are represented by two species of Cratægus and two of Prunus, one of the latter being more or less open to question. *Cratægus flavescens* Newberry, from Bridge Creek, is a well-marked species. It is undoubtedly similar to what was called *C. flava* Ait., but which has now been segregated into several closely allied forms. Lesquereux's *Myrica diversifolia* is clearly the same as *C. flavescens* and has been united with it. A form quite similar to *flavescens*, but undoubtedly distinct, I have called *C. imparilis*. It is a small seven-lobed leaf.

The form that I have named *Prunus? Merriami* is a small ovate leaf with finely serrate margins, and in appearance quite like some forms of the living *P. virginiana*, *P. demissa*, etc. It also resembles some species of Cydonia, as *C. japonica*.

Closely related to *P. Merriami*, and possibly identical with it, is what I have called *P. tufacea*. It is from the same beds, but differs in a number of minor particulars, being elliptical or slightly elliptical-obovate instead of ovate, and has finer, more regular, and evidently sharper-pointed teeth.

The family Mimosaceæ is represented by a single pod, which was named *Acacia oregoniana* by Lesquereux.

The presence of the Cæsalpinaceæ in this flora is open to doubt, as it depends solely on the problematical form referred to Cassia by Newberry. Judging from the drawing alone, it would be concluded at once that it represented a small pod, but a careful study of the type specimen shows that this is not a fair interpretation. It may be a small pod, but this is extremely doubtful, and even granting this, the reference of it to Cassia is open to the gravest question.

The presence of the Simarubaceæ rests on what Lesquereux has identified as a species of Ailanthus. This consists of a branch and a number of samaras, all preserved in the same piece of matrix. In the first place, they have not been correctly described and figured by

Lesquereux, and beyond this remains the further question of the correctness of their reference to Ailanthus.

The Anacardiaceæ were but poorly represented, there being only one species and a doubtful form referred to Rhus.

The Celastraceæ are represented by two species of Celastrus, both from the Mascall beds.

Next to the Betulaceæ and Fagaceæ the Aceraceæ appear to have been the most important family in this flora. It is represented by two genera, Acer, with eleven nominal forms, and Rulac (Negundo), with one.

The maples appear to have been absent at the time the lowest of the plant-bearing beds of the region were deposited; at least no remains of them have been discovered. In the Clarno formation maples are rare, a single species (*A. Osmonti*) having been found at Bridge Creek and doubtful forms at the same place and near Clarnos Ferry. *Acer Osmonti* is a fine species, very modern in appearance, suggesting at once the living *A. saccharum* and small leaves of *A. macrophyllum*, the common maple of the coast.

Maples were undoubtedly abundant at the time the Mascall beds were laid down, for numerous leaves, fruits, and branches are present. The most abundant of the species founded on the leaves is Lesqureuex's *A. Bendirei*, which was for a time supposed to be the same as the European *A. trilobatum productum* (Al. Br.) Heer. They are large, deeply lobed and toothed leaves. *A. dimorphum* Lesq. is different entirely from the last, and its status is possibly still open to more or less question. What I have called *A. Merriami* is wholly unlike *A. Bendirei*, but may be a very broad, coarsely toothed form of *A. dimorphum*. It is, however, without the basal lobes so conspicuous in *dimorphum*.

Associated throughout the beds with the leaves are numerous specimens of maple fruits. It is not possible to characterize these fruits with entire satisfaction, but largely on the basis of size, as well as other minute characters, I have ventured to give names to these species: *A. oregonianum*, *A. medianum*, and *A. minor*. It is possible that only two species of fruits are represented, but the differences in size would seem to be greater than are found in any one living species. In the same beds was found a single specimen of a maple fruit which I have named *Acer gigas*. It is a long, narrow fruit, 9.5 cm. in length, and, so far as I know, is the largest fruit of the kind thus far described.

Under the name of *Rulac cratægifolium* I have described a compound leaf that is certainly very suggestive of the living box elder. It is unfortunately not quite perfect, and its form and other characters are made out with difficulty.

The Hippocastanaceæ are represented by a single but undoubted species of Æsculus, which, from its close approach to certain living

forms, I have called *Æ. simulata*. It is clearly related to *Æ. octandra* and *Æ. glabra*, both well-known species of the Eastern United States.

The Sapindaceæ are represented by four species of Sapindus, but by a relatively small number of specimens. Under the name of *S. Merriami* I have characterized a small species from Bridge Creek. It seems closest to some of the smaller leaflets of *S. obtusifolius* Lesq., but has smaller and thinner secondaries. The other species are all found in the Mascall beds, and are each represented by single specimens. This family was clearly not of great importance.

The Rhamnaceæ, although represented by two species, are few in numbers and evidently played an unimporant rôle.

To the Tiliaceæ are referred two species of Grewia, one of which, *G. crenata*, is a well-known European Miocene species. It is most abundant in the beds at Bridge Creek, but a few examples have also been found in the Mascall beds at Van Horn's ranch. The other form, *G. auriculata* Lesq., rests on the single type specimen, no others having been obtained. It is possible that it is only an abnormal leaf of *G. crenata*.

The family Araliaceæ is represented by two named forms, and a number so poorly preserved as to render specific identification unsafe. Thus *A. digitata* Ward is found in the lowest or Cherry Creek locality. In the same beds is another broken specimen that was referred to *Aralia notata* by Lesquereux, but it is too fragmentary to permit of a satisfactory specific determination. The locality 3 miles above Clarnos Ferry has afforded two fragments, evidently representing quite distinct species of Aralia, but they are too poor to warrant specific naming. The Mascall beds afford a single specimen that is referred with some doubt to *A. Whitneyi*. It is a smaller leaf than is usual in this species.

The families Cornaceæ and Ericaceæ are represented by a single species each, the first by *Cornus ferox*? Unger and the latter by *Andromeda crassa* Lesq.

The Ebenaceæ are represented by two species of Diospyros, *D. alaskana* Schimper, in the Cherry Creek deposits, and *D. elliptica*, a new form from the Mascall beds. The latter has the nervation of living American species, but is more obtuse at apex than is usual in these leaves.

The Oleaceæ, although represented by only two species of Fraxinus, both from Bridge Creek, was of considerable prominence, judging from the number of individuals present. *Fraxinus integrifolia* Newb., is a very thick, coriaceous-leaved species.

Under the name of Phyllites there are a number of peculiar forms. Some of these are well preserved and may later be referred to more distinctive places; others are mere fragments too small for adequate determination.

GEOLOGICAL CONSIDERATIONS.

We now come to a consideration of the bearing of the fossil flora on the age of the beds involved. I took occasion to say in my report on the plants obtained by the expeditions of the University of California, under the charge of Dr. Merriam: "In attempting to work out the bearing of the plants above enumerated on the question of the age of the beds it should not be overlooked that any conclusions drawn might be quite different from what they would be were the whole flora of each of the localities to be considered."[a] I added, however, that the conclusions then expressed were "not likely to be greatly modified by subsequent work." The truth of this prediction has been satisfactorily confirmed, for after a full consideration of every known species or form, from every known locality, no evidence was forthcoming to modify the conclusions then expressed. In the following pages the evidence on which these conclusions rest will be set forth more fully than the space then at my disposal would permit.

A reference to the table given on pages 89-92 shows that the bulk of the flora of the John Day Basin has come from Cherry Creek, Bridge Creek, and Van Horn's ranch and vicinity. Very few species are common to two or more of these localities. The species found at the several other scattered localities, as will be shown later, naturally fall under one or another of these three.

LOWER CLARNO BEDS.

CHERRY CREEK.

The flora of Cherry Creek, to which may be added that from Currant Creek, which is clearly the same horizon and only a short distance away, comprises 22 forms, as follows:

Lygodium Kaulfusii Heer.	Ficus tenuinervis Lesq.
Asplenium subsimplex (Lesq.) Kn.	Magnolia lanceolata? Lesq.
Pteris pseudo-pinnæformis Lesq.	Magnolia Culveri Kn.
*Lastrea Fischeri? Heer.	Cinnamomum Dilleri Kn.
*Equisetum oregonense Newb.	*Rhamnus Cleburni var Lesq.
*Salix Schimperi Lesq.	Aralia digitata Ward.
Juglans rugosa Lesq.	Aralia sp.
Juglans? Bendirei n. sp.	*Cornus ferox? Unger.
Hicoria? oregoniana n. sp.	Diospyros alaskana Schimp.
Quercus furcinervis americana Kn.	*Phyllites wascoensis Lesq.
Quercus sp.	Phyllites sp.

Of the forms above listed 2 are new to science, 3 are not named specifically, while 6 (those marked with an asterisk) have not been reported outside these beds, leaving 11 species, or exactly 50 per cent,

[a] Univ. Cal., Bull. Dept. Geol., Vol. II, No. 9, p. 290.

enjoying a distribution beyond the limits of the John Day Basin. Their distribution is shown in the following table:

Table showing the extralimital distribution of the fossil plants from the Cherry Creek locality.

Species.	Laramie.	Denver.	Eocene in general.	Fort Union.	Green River.	Miocene.	Remarks.
Lygodium Kaulfusii			×				
Asplenium subsimplex		×					
Pteris pseudo-pinnæformis		×					
Juglans rugosa	×	×	×?	×			
Ficus tenuinervis					×		
Quercus furcinervis americana						×?	Plumas County, Cal.
Magnolia lanceolata?						×	
Magnolia Culveri						×	Lamar flora.
Cinnamomum Dilleri			×				
Aralia digitata				×			
Diospyros alaskana	×?		×?				

A study of this table brings out the fact that only four of the eleven species have been found above the Fort Union beds. Of these four, *Quercus furcinervis americana* is doubtfully reported from the supposed Miocene of Plumas County, California, and *Magnolia lanceolata* is doubtfully identified in the Cherry Creek beds. *Ficus tenuinervis* was described originally from the Green River beds of Wyoming, and *Magnolia Culveri* from the Lamar beds of the Yellowstone National Park. The remainder have been found in the Laramie, Denver, Fort Union, and the Eocene in general.

Of the species previously known but not found outside the Cherry Creek beds, *Rhamnus Cleburni* var. is closely allied to *R. Cleburni* of the Denver beds, and *Cornus ferox* is allied to an Eocene species.

From these considerations it appears that the plants of the Cherry Creek locality point to the lower Eocene age of the beds.

UPPER CLARNO BEDS.

BRIDGE CREEK.

The flora of Bridge Creek comprises 45 forms, as follows:

Sequoia Heerii Lesq.
Sequoia Langsdorfii (Brgt.) Heer.
Monocotyledonous plant.
Juglans Schimperi? Lesq.
Juglans acuminata? Al. Br.
Juglans cryptata n. sp.
Juglans, nut of.
Hicoria? sp.
Carpinus betuloides Unger.
Corylus MacQuarrii (Forbes) Heer.
Betula heteromorpha n. sp.
Betula heterodonta Newb.

Betula Bendirei n. sp.
Betula angustifolia Newb.
Alnus carpinoides Lesq.
Alnus serrulata fossilis Newb.
Alnus macrodonta n. sp.
Alnus sp., fruit of.
Alnus Kefersteinii (Göpp.) Unger.
Quercus paucidentata Newb.
Quercus drymeja Unger.
Quercus simplex Newb.
Quercus affinis (Newb.).
Quercus consimilis Newb.
Quercus Breweri Lesq.
Quercus oregoniana n. sp.
Ulmus speciosa Newb.
Ulmus Newberryi n. sp.
Ficus planicostata Lesq.
Berberis simplex Newb.
Cinnamomum Bendirei n. sp.
Liquidambar europæum Al. Br.
Platanus aspera Newb.
Platanus Condoni (Newb.).
Cratægus flavescens Newb.
Cassia? sp. Newb.
Ailanthus ovata Lesq.
Acer Osmonti n. sp.
Acer sp.
Sapindus Merriami n. sp.
Rhamnus Eridani Unger.
Grewia crenata (Ung.) Heer.
Grewia auriculata Lesq.
Fraxinus integrifolia Newb.
Fraxinus denticulata? Heer.

Of the 45 forms here enumerated, 6 have not been specifically named and 9 are new, leaving 30 previously known, of which 16 have not been found outside of these beds. It thus appears that about 30 per cent of the entire flora, or 14 species, has an outside distribution. None of these are found in the Cherry Creek beds and only 2 in the Mascall beds. The distribution of these 14 species is shown in the following table:

Table showing extralimital distribution of fossil plants from Bridge Creek locality.

Species.	Upper Cretaceous.	Laramie.	Denver.	Livingston.	Fort Union.	Eocene in general.	Eocene of Alaska.	Green River.	Miocene.	Remarks.
Sequoia Heerii	....	....	....	....	....	....	×	×?	....	
Sequoia Langsdorfii	×?	....	....	....	×	×	×	×	×	
Juglans Schimperi	....	....	×	....	×	....	....	×	....	
Juglans acuminata	....	....	....	....	....	....	×	....	....	
Betula angustifolia	....	....	....	....	....	....	....	....	....	Payette formation.
Carpinus betuloides	....	....	....	....	....	....	....	....	....	
Alnus Kefersteinii	....	....	....	....	....	....	×	....	....	
Quercus drymeja	....	....	....	....	....	....	....	×	....	
Quercus Breweri	....	....	....	....	....	....	....	....	×?	
Ficus planicostata	....	×	×	....	....	....	....	....	....	
Liquidambar europæum	....	....	....	....	....	....	×	×	....	
Rhamnus Eridani	....	....	....	....	....	×	....	....	....	
Grewia crenata	....	....	....	....	×?	....	....	....	....	
Fraxinus denticulata?	....	×?	....	×	....	....	....	....	....	

This table brings out the fact that the plants of Bridge Creek, when found outside, belong to a higher horizon. One—*Sequoia Langsdorfii*—has been reported from the Upper Cretaceous at Nanaimo, British

Columbia, but it is doubtful if it has been correctly determined. Otherwise, this species is found from the Fort Union to the Miocene. *Ficus planicostata* is of rather doubtful occurrence at Bridge Creek. It is a Laramie and Denver species. *Fraxinus denticulata* is also a doubtful form at Bridge Creek; it has been reported from Evanston, Wyoming, in beds supposed to be of Laramie age, and in the Livingston beds of Montana. *Juglans Schimperi* is found in the Denver beds at Golden, Colorado. The remaining species are all found in or above the Fort Union beds. Two are found in the Eocene in general, 5 in the so-called Eocene of Alaska, 5 in the Green River beds of Wyoming, and 2 (one of which is doubtful) in the Miocene.

The conclusion reached in my preliminary paper—that these beds should be regarded as Upper Eocene in age—appears to have been justified. The fact of this higher distribution than the plants of Cherry Creek is further emphasized by a review of the species related to the forms indigenous to these beds. Thus, the species described as *Juglans cryptata* is closely related to *J. denticulata* Lesq., from the Green River, Wyoming, and other localities. *Quercus consimilis* is related to *Q. drymeja*, reported in this country from the Green River. *Quercus simplex* is related to *Q. consimilis*, differing merely by the entire margin, while *Q. Breweri* is similarly closely related, differing in being much longer and narrower. *Ulmus speciosa* is suggestive of *U. Braunii*, found in this country in the Green River beds at Florissant, Colorado. The species I have described as *U. Newberryi* is close to *U. speciosa*, being smaller and narrower. *Platanus Condoni* is clearly related to *P. basilobata* of the Fort Union beds of Montana, being evidently a more highly developed form than that species. *Cratægus flavescens*, which, as already pointed out, is the same as Lesquereux's *Myrica diversifolia* as identified by him at Bridge Creek, is certainly very similar to the originals of this from Florissant, Colorado. This list could be further extended if necessary.

OTHER LOCALITIES.

There are a number of other localities discovered by Dr. Merriam that are evidently the same age as Bridge Creek. None of them have afforded a flora of more than three or four species. They are as follows:

ONE AND ONE-HALF MILES EAST OF CLARNOS FERRY.

From this locality the following species have been obtained:

Sequoia Langsdorfii (Brgt.) Heer.
Alnus carpinoides Lesq.
Acer sp.

ONE-HALF MILE NORTHEAST OF FOSSIL.

This locality has yielded the following:

Sequoia Langsdorfii (Brgt.) Heer.
Myrica? personata n. sp.
Alnus carpinoides Lesq.

OFFICER'S RANCH, BUTLER BASIN.

The following species are found:

Quercus simplex Newb.
Quercus consimilis Newb.
Platanus Condoni (Newb.) Kn.

These species, wherever previously known, are identical with those from Bridge Creek, and the beds are referred to the same age.

MASCALL BEDS.

VAN HORN'S RANCH AND VICINITY.

This flora is by far the richest thus far found in the John Day Basin. Following is a list of the forms identified:

Equisetum sp.
Ginkgo sp.
Sequoia Langsdorfii (Brgt.) Heer.
Sequoia angustifolia Lesq.
Sequoia sp.
Thuites sp.
Glyptostrobus Ungeri Heer.
Taxodium distichum miocenum Heer.
Taxodium, male aments of.
Phragmites œningensis Al. Br.
Cyperacites sp.
*Smilax Wardii Lesq.
Populus Lindgreni Kn.
*Salix Engelhardti Lesq.
Salix Ræana? Heer.
Salix varians Göpp.
Salix angusta Al. Br.
Salix amygdalæfolia Lesq.
Salix pseudo-argentea n. sp.
Salix dayana n. sp.
Salix perplexa n. sp.
Salix mixta n. sp.
Myrica oregoniana n. sp.
Juglans oregoniana Lesq.
*Hicoria elænoides (Ung.) Kn.
Carpinus grandis? Ung.
Betula? dayana n. sp.
Alnus Kefersteinii? (Göpp.) Unger.
Fagus? sp.
*Quercus pseudo-lyrata Lesq.
Quercus Merriami n. sp.
Quercus duriuscula n. sp.
Quercus ursina n. sp.
Quercus dayana n. sp.
*Quercus horniana Lesq.
Quercus? sp. Kn.
Ulmus plurinervia Ung.
Ulmus californica? Lesq.
Planera Ungeri Ett.
*Ficus? oregoniana Lesq.
Artocarpus californica? Kn
Magnolia lanceolata Lesq.
Magnolia Inglefieldi Heer.
Berberis? gigantea n. sp.
Laurus oregoniana n. sp.
*Hydrangea Bendirei (Ward) Kn.
Liquidambar europæum patulum n. var.
*Liquidambar protensum? Ung.
Liquidambar pachyphyllum n. sp.
Liquidambar sp.
Platanus nobilis? Newb.
Platanus aceroides? (Göpp.) Heer.
Platanus sp.
Cratægus imparilis n. sp.
Prunus? Merriami n. sp.
Prunus tufacea n. sp.
*Acacia oregoniana Lesq.
*Rhus Bendirei Lesq.
Rhus? sp. Lesq.
Celastrus dignatus n. sp.
Celastrus confluens n. sp.
Acer Bendirei Lesq.
*Acer dimorphum Lesq.
Acer Merriami n. sp.
Acer, branches of.
Acer oregonianum n. sp.
Acer medianum n. sp.
Acer minor n. sp.
Acer gigas n. sp.
Rulac cratægifolium n. sp.
Æsculus simulata n. sp.
Sapindus obtusifolius Lesq.
Sapindus angustifolius? Lesq.
Sapindus oregonianus n. sp.
Grewia crenata (Ung.) Heer.
*Andromeda crassa Lesq.
Diospyros elliptica n. sp.
Phyllites bifurcies n. sp.
Phyllites inexpectans n. sp.
Phyllites personatus n. sp.

The total number of forms represented is 80, of which number 11 have not been specifically named, and 30 species and 1 variety are described as new to science. The remainder, or 37 species, are those previously known from these beds. Of these 37 species, 12 (those marked with an asterisk in the preceding list) have not been found beyond the limits of these beds, leaving 25 species which have an outside distribution. This distribution is shown in the following table:

Table showing extralimital distribution of fossil plants from Van Horn's ranch and vicinity.

Species.	Fort Union.	Eocene in general.	Green River.	Eocene of Alaska.	Miocene.	Remarks.
Sequoia Lansgdorfii	×	×	×	×	×	Upper Cretaceous.
Sequoia angustifolia	....	....	×?	×	×	
Glyptostrobus Ungeri	....	....	×	×?	×	
Taxodium distichum miocenum	×	×	....	....	×	
Phragmites œningensis	....	....	....	....	....	Laramie to Pliocene.
Populus Lindgreni	....	....	....	....	×	
Salix Ræana?	....	....	....	×	×	
Salix varians	....	....	....	×	....	
Salix angusta	....	....	....	....	....	Whole Tertiary.
Salix amygdalæfolia	....	....	×	....	×	
Juglans oregoniana	....	....	....	....	×	
Carpinus grandis?	....	×	×	....	×	
Alnus Kefersteinii?	....	....	....	×	×	
Ulmus plurinervia	....	....	....	×	....	
Ulmus californica?	....	....	....	....	×	
Artocarpus californica?	....	....	....	....	×	
Magnolia lanceolata	....	....	....	....	×	
Magnolia Inglefieldi	....	....	×?	....	....	Lassen County, Cal.
Platanus nobilis?	×	×?	....	....	....	
Platanus aceroides?	....	....	....	....	....	Laramie to Miocene.
Acer Bendirei	....	....	....	....	×	
Sapindus obtusifolius	×	....	....	....	....	
Sapindus angustifolius?	....	×	×	....	×	
Grewia crenata	×?	×	....	....	....	Bridge Creek.

In my report on the collection of plants from Van Horn's ranch[a] and vicinity obtained by Dr. Merriam I made the following statement: "The flora of the Van Horn ranch finds its greatest affinity with that of the Auriferous gravels and with allied floras of California, and is to be regarded as upper Miocene in age." Since writing this I have brought out the fact, already set forth, that certain of the species most relied upon in making this correlation, such as *Quercus pseudo-*

[a] Univ. Cal., Bull. Dept. Geol., Vol. II, No. 9, p. 309.

lyrata, *Juglans oregoniana*, etc., that were supposed to have come from the Auriferous gravels, are in reality confined to the Van Horn's ranch locality. This correlation therefore fails, and the age of the Van Horn's ranch material must be fixed in other ways.

The table on the preceding page shows at a glance that the geologic horizons of those species found outside these beds are decidedly higher than those of either of the floras previously considered. Thus, 17 species out of 25 are found in the Miocene. The oldest beds represented, at least by species having any particular value for fixing the age, is the Fort Union, which contains 5 or 6 of the species listed. *Sequoia Langsdorfii* extends throughout the entire Tertiary, and possibly even into the Upper Cretaceous. *Phragmites œningensis* extends from the Laramie to the Pliocene, but it is at best a doubtful organism, hard to identify satisfactorily. *Salix angusta* is another species ranging throughout the Tertiary, but it is simply a narrow-leaved willow that may or may not be the same form at all points where it has been reported. Seven of the species enumerated, 2 of which are doubtful, are found in the Green River beds, and 6, one of which is open to question, have been found in the Eocene in general. Seven species are found in the so-called Eocene of Alaska, which was, until recently, regarded as of Lower Miocene age.

If dependence were placed exclusively on the distribution of the above-mentioned forms in fixing the age of these beds, the tendency would be to regard them as not younger than Lower Miocene, or even possibly as old as the Upper Eocene, but when we take into account the affinities and relationships of the forty or more named species that are confined to these beds, the preponderance of evidence would seem to relegate them to an age as young as Upper Miocene. Thus the species of Salix are closely allied to various living species, such as *S. argentea*, etc. The species of Quercus are distinctly modern. *Quercus pseudo-lyrata* is hardly to be distinguished from *Q. lyrata; Q. Merriami* is also near *Q. lyrata; Q. duriuscula* is very close to *Q. minor*, and *Q. ursina* to the living *Q. nana*. The form referred to *Artocarpus californica*, if correctly identified, is close to the living *A. incisa; Hydrangea Bendirei* is closely related to several living species; and the species of Liquidambar are not far from *L. Styraciflua*. The two species referred to Prunus are close to the living *P. demissa*, *P. virginiana*, etc. The maples are very modern in appearance, being related to *A. saccharum*, *A. macrophyllum*, etc., and the box elder is not far from the living species. The species described as *Æsculus simulata* is similar to *Æ. octandra* and *Æ. glabra*.

Taking all lines of evidence into account, it seems warranted to refer these beds to the Upper Miocene.

THE FLORA OF THE JOHN DAY BASIN IN OTHER LOCALITIES.

Before leaving this subject it may be of interest to give a short account of this flora as it has been recorded at several localities beyond the limits of the John Day Basin. This is especially desirable since we now have for the first time a definite knowledge of the geological sequence of the plant-bearing beds in the basin. Up to the date of the publication of Dr. Merriam's paper on the geology of the basin our knowledge of the interrelations of the plant beds has been in a much confused state. This confusion is in large measure due to the fact that no definite localities were given by Lesquereux, they being simply recorded as "John Day Valley, Oregon," and so it came to be supposed that all species from this area were of the same age. This confusion was helped along by Newberry, who placed Cherry Creek, Currant Creek, and Bridge Creek in the same horizon, which he referred to the Miocene. In his latest publication on the subject (Proc. U. S. Nat. Mus., Vol. XI. pp. 13–24) Lesquereux referred the beds at Cherry Creek to the Laramie and the Van Horn's ranch deposits to the Miocene, but he made no attempt to give more definite localities for the forms mentioned in his earlier reports. It was possible to settle the exact locality of these species only by a careful study of the types, which are the property of the University of California. This investigation, as already set forth, has been made, and the results are incorporated in the foregoing pages. But the confused condition of our knowledge of this flora has made its impress on determinations of the plants whenever they have been found beyond the limits of the John Day Basin. These outside floras will be passed in review and the attempt will be made to adjust them to accord with our present fuller knowledge of the type section.

So far as I now know, the first recognition of the flora of the John Day Basin beyond the original limits was made by myself in a "Report on fossil plants from near Ellensburg, Washington," which was published in 1893 as an appendix to Bulletin 108 of the United States Geological Survey, by Prof I. C. Russell, entitled "A Geological Reconnoissance in Central Washington." Ten species were enumerated in this collection as follows:

Salix varians Göpp.	Ulmus pseudo-fulva Lesq.
Populus glandulifera Heer.	Platanus dissecta Lesq.
Populus Russelli Kn.	Platanus aceroides? (Göpp.) Heer.
Alnus? sp.	Paliurus colombi Heer.
Ulmus californica Lesq.	Magnolia lanceolata Lesq.

Some of these forms were recognized by Lesquereux as occurring at Van Horn's ranch, although they have not all been admitted in the present paper. *Populus glandulifera* was based on a single example,

which I have considered as too indefinite to be entitled to recognition, and *Paliurus colombi* has been referred to *Grewia crenata*. The examples representing these species at Ellensburg are more numerous and better preserved, and are probably correctly determined. *Salix varians*, which is represented at Van Horn's ranch by a very few examples, is extremely abundant at Ellensburg, and I have also recognized in this material one of the new species of Salix (*S. pseudo-argentea*) from the Mascall beds. A number of the Ellensburg species are also common to the Auriferous gravels of California.

As I pointed out in the report on the Ellensburg material, there can be no doubt that it is of the same age as that at Van Horn's ranch, a condition further emphasized by the similarity in the matrix, that from both localities being a white, soft, fine-grained volcanic ash.

In 1892 Mr. J. S. Diller made a small collection of fossil plants at a point 6 miles southeast of Ellensburg, Washington, that contains, among other species, some well-preserved examples of *Platanus dissecta*. The matrix is also similar to that at Ellensburg and Van Horn's ranch, and the age of the beds is undoubtedly the same.

In 1898 I published a report[a] on the Fossil Plants of the Payette Formation. The name Payette formation was given by Mr. Waldemar Lindgren to a series of lake beds along the Snake River, in western Idaho. The flora here enumerated embraced 32 forms, of which number 17 were described as new and 5 were not specifically named, leaving, as then known, only 10 species having an outside distribution. On page 736 of this report I gave a table showing the extralimital distribution of these 10 species. On referring to this table it will be seen that 5 of these species are found only in the beds at Bridge Creek, and to this list I am now able to add another species (*Sequoia angustifolia*), thus making 6 of the 10 species common to these two localities. A number of forms that I described as new are undoubtedly related to Bridge Creek species. Thus *Quercus simulata* is related to *Q. simplex*, and *Q. idahoensis* and *Q. payettensis* are both more or less closely related to *Q. consimilis*. Two species (*Juglans hesperia*, which I have now referred to *J. oregoniana* Lesq., and *Populus Lindgreni*), described as new in the Payette formation, have been detected in the Mascall beds at Van Horn's ranch.

In this report the Payette formation was referred to the Upper Miocene, but I was misled by the knowledge then current regarding the position of the Bridge Creek beds, as I have already pointed out, and it is now necessary to change that reference. The flora of the Payette formation undoubtedly finds its greatest affinity with that at Bridge Creek, a fact recognized all along, and, like it, is now referred

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[a] Eighteenth Ann. Rept. U. S. Geol. Survey, Pt. III, pp. 721-744; Pls. XCIX-CII.

to the Upper Eocene. It may be noted, though the fact is perhaps not of great importance, that the matrix in which the plants of the Payette formation are preserved is similar to that at Bridge Creek.

In 1900 I published a short paper on the Fossil Plants associated with the Lavas of the Cascade Range,[a] which accompanied a paper by Mr. J. S. Diller, on The Bohemia Mining Region of Western Oregon, with notes on the Blue River Mining Region and on the Structure and Age of the Cascade Range. It was with the latter portion of Mr. Diller's paper that my own had especial connection. This paper was based on small collections that had been made by Mr. Diller and others. Six localities were represented, as follows: (1) Left bank of the Columbia River, near the mouth of Moffats Creek; (2) Comstock, Douglas County; (3) 1 mile east of Murphys Springs, southeast of Ashland; (4) Coal Creek, Lane County; (5) 5 miles directly north of Ashland; and (6) 3 miles southeast of Ashland. The entire flora comprised only 28 forms, of which 10 were described as new to science and 7 were not named specifically, leaving but 11 species with previously known distribution. No locality was represented by more than 10 forms and most of them by from 2 to 5 forms.

The species composing this flora were compared with those from the John Day Basin and the Auriferous gravels of California, and were referred to the Miocene. In the light of our present knowledge of the type section in the John Day Basin, certain modifications of this reference seem necessary. I hesitate, however, to make radical changes in my former determination without additional material. When taken as a unit this flora is undoubtedly similar to that of the John Day Basin, considered as a whole, but when an attempt is made to relegate the species from individual localities to one of the three horizons now recognized in the basin, the meagerness of the material becomes very apparent. With the exception of the first of the localities to be mentioned, the following tentative classification may be made: The locality on the Columbia River near the mouth of Moffats Creek contains *Acer Bendirei* and a doubtful leaf of *Populus Zaddachi*. The first of these species is so characteristic that I have little or no hesitation in referring it to the same age as the Van Horn's ranch material, namely, Upper Miocene. The localities 5 miles north of Ashland and 3 miles southeast of Ashland seem to be more closely allied to Bridge Creek and are probably to be regarded as Upper Eocene in age. Murphys Springs is also probably the same in age as Bridge Creek, while Coal Creek, in Lane County, and Comstock, in Douglas County, seem likely to be older Eocene than the Bridge Creek beds. But I wish to emphasize the fact that these are purely tentative views, and we must depend upon fuller collections to settle the points at issue.

[a] Twentieth Ann. Rept., U. S. Geol. Survey, Pt. III, pp. 37-64, pls. 1-5.

THE DALLES, OREGON.

By the kindness of Dr. Arthur Hollick I have been enabled to examine a number of unpublished plates of fossil plants by the late Dr. Newberry, on which are depicted several species from the so-called Dalles group, at the Dalles of the Columbia. The matrix, I am informed by Dr. Hollick, is a whitish, very coarse-grained volcanic ash, identical in appearance with that bearing fossil plants at Kelly Hollow, Wenas Valley, near Ellensburg, Washington. These plates were not published by Dr. Newberry and simply bear provisional names penciled on the margins of the plates. These species are represented as follows:

Acacia, or *Cassia* sp.—A small, even-pinnate compound leaf of numerous small oblong leaflets. Nothing similar has been thus far found in the John Day Basin.

"*Myrica diversifolia* Lesq."—Two figures of this form are shown. They appear to be the same as *Cratægus flavescens* Newb., from Bridge Creek.

"*Ulmus* sp."—Two small, coarsely toothed leaves with well-marked secondaries ending in the marginal teeth. Judging from the drawings alone I should incline to refer these leaves to a small form of *Carpinus grandis* Unger, very similar to some forms found at Bridge Creek, and not to Ulmus. They are wholly unlike the common elm leaves that are abundant at this latter locality.

With only these data available I should incline to regard the locality affording them as referable to the same age as the Bridge Creek beds, viz, Upper Clarno.

From the facts here adduced it seems beyond dispute that the conditions which prevailed in the John Day Basin during Tertiary times were much more far reaching than the mere local limits of the basin; in other words, that the formations there recognized extended as far north as central Washington, east into northwestern Idaho, and westward over much of western Oregon.

SUMMARY.

(1) The John Day Basin lies between the north and south ranges of the Blue Mountains, in north-central Oregon. It covers an area of approximately 10,000 square miles and is drained by John Day River and its tributaries. It has been the scene of great volcanic activity, its rock masses being made up of numerous volcanic flows, with alternations of ashes, tufas, sands, and gravels.

(2) No detailed geological study has been made of the region, but contributions to this subject have been made by Le Conte, Condon, Marsh, Cope, Wortman, Matthew, and Merriam, the most important and comprehensive being by the latter author.

(3) Its fossil riches, in the shape of mammalian teeth, were first brought to scientific attention in 1861. Since that time an extensive vertebrate fauna has been described by Leidy, Cope, Marsh, Wortman, Merriam, and others.

(4) The first fossil plants were found at Bridge Creek in 1862, by Prof. Thomas Condon. Since that date collections of plants have been made by Condon, Voy, Bendire, Merriam, Osmont, and Knowlton. The plants have been studied and described by Newberry, Lesquereux, and Knowlton.

(5) The fossil flora of the John Day Basin, as set forth in the present paper, comprises 150 forms, distributed among 37 natural families and the anomalous group of Phyllites. Of the 150 forms enumerated, 24 have not been named specifically, and 44 species and 1 variety are described as new to science. The previously known species number 81.

(6) The known fossil floras of the John Day Basin are all of Tertiary age. The oldest, represented by the localities of Cherry Creek, Currant Creek, and 3 miles above Clarnos Ferry, is referred to the Lower Eocene. It is in the lower part of Merriam's Clarno formation. The next younger in age, exposed at Bridge Creek, 1½ miles east of Clarnos Ferry, one-half mile northeast of Fossil, and Officer's ranch in the Butler Basin, occupies the upper part of the Clarno formation and is Upper Eocene in age. The youngest plant-bearing beds of the region, found at Van Horn's ranch and vicinity, are in the basal portion of the Mascall formation. The age is regarded as Upper Miocene.

(7) From the facts adduced in this bulletin it is concluded that the conditions which prevailed in the John Day Basin during Tertiary times extended also into central Washington, northwestern Idaho, and western Oregon.

PLATES.

PLATE I.

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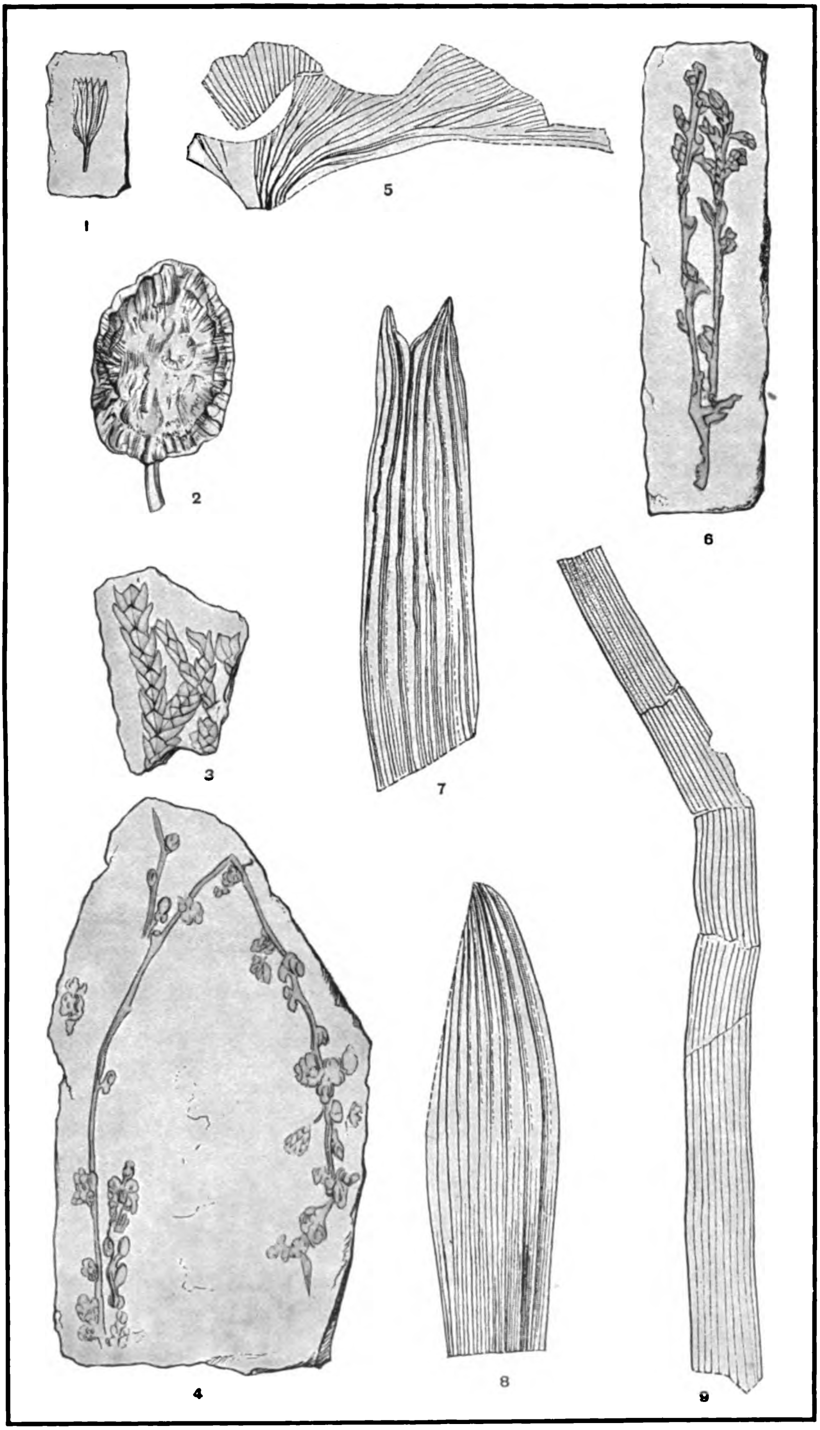
PLATE I.

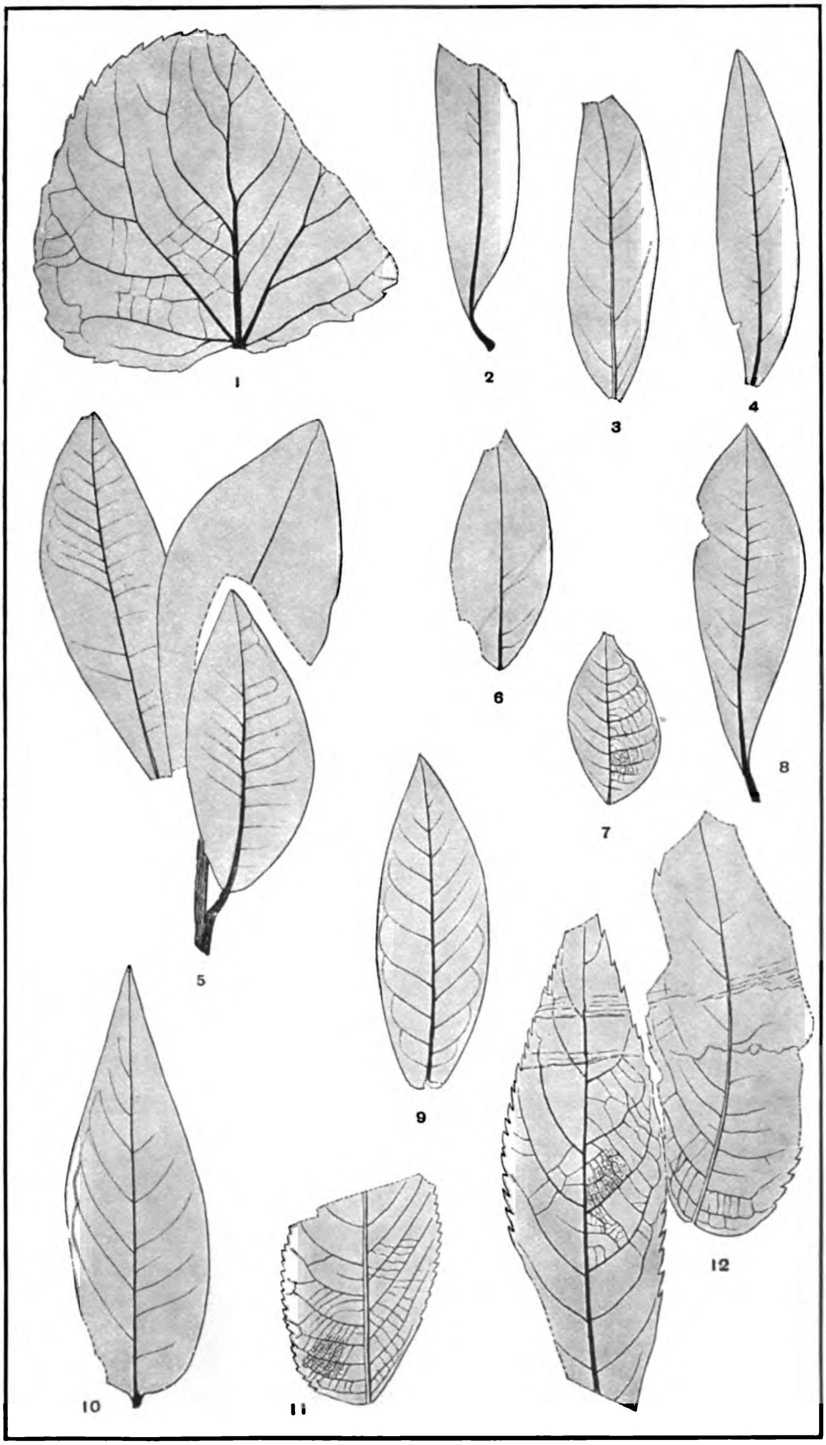


FOSSIL FLORA OF THE JOHN DAY BASIN.

PLATE II.

PLATE III.

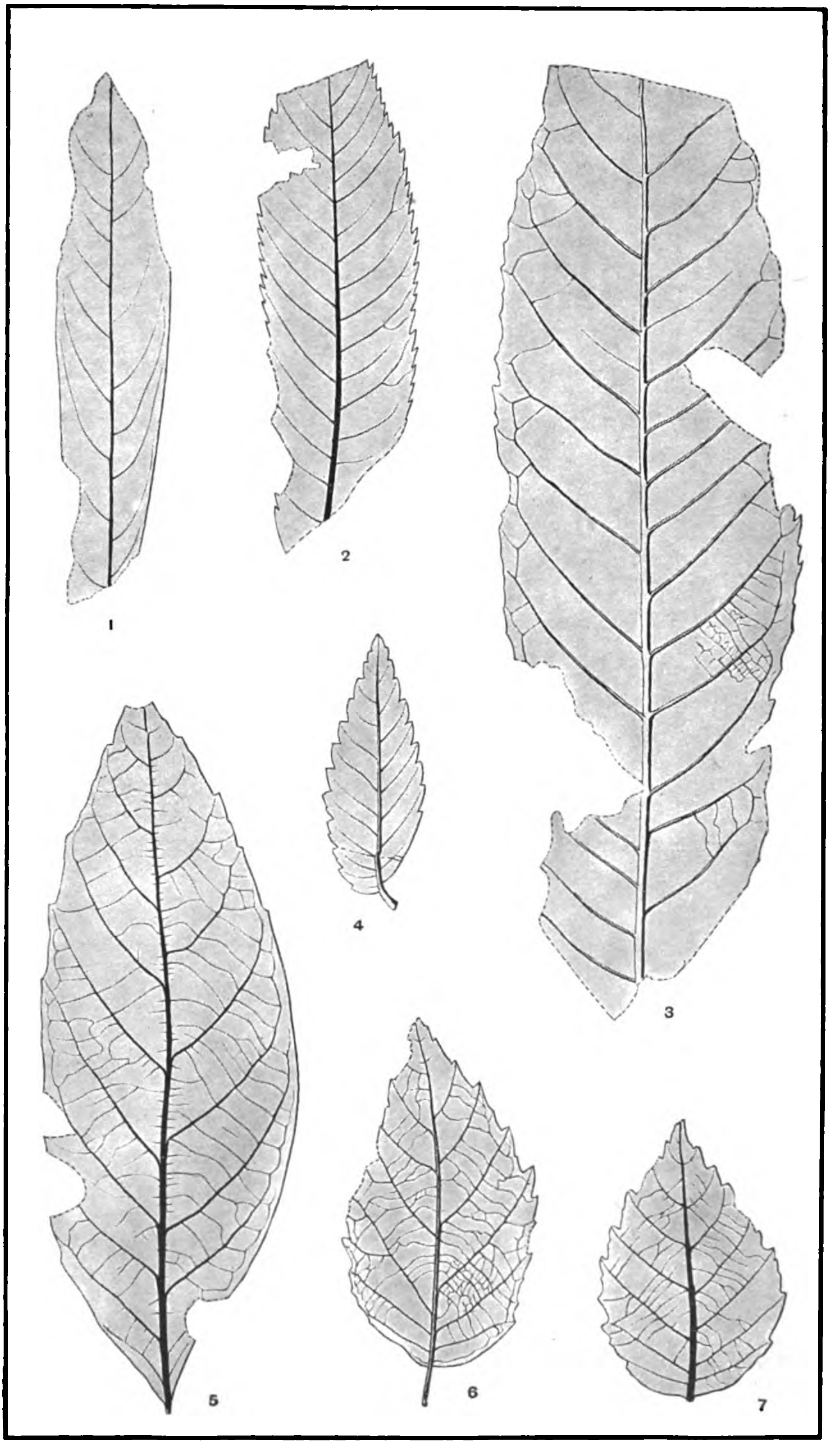
PLATE II.



FOSSIL FLORA OF THE JOHN DAY BASIN.

PLATE III.

PLATE III.



FOSSIL FLORA OF THE JOHN DAY BASIN.

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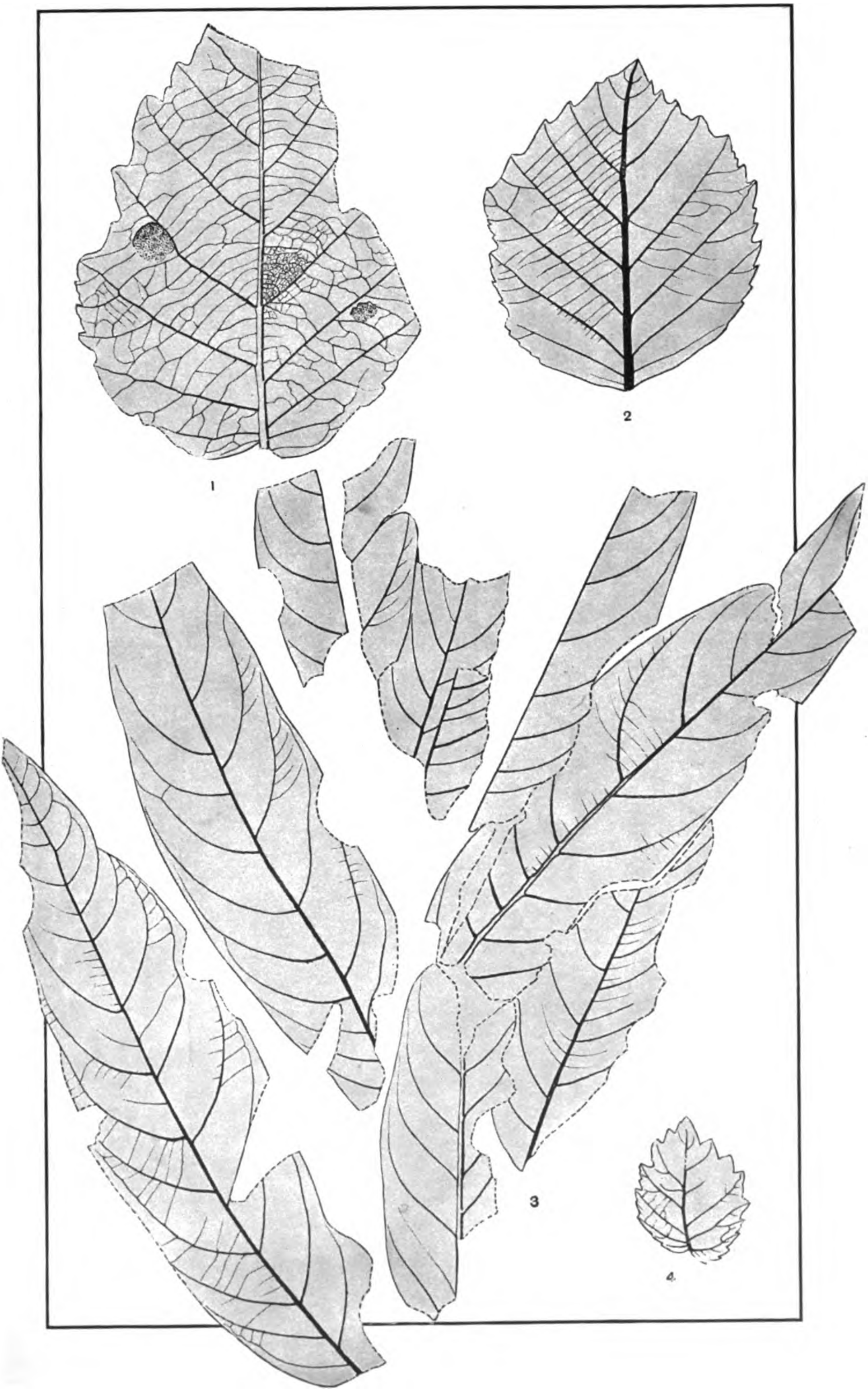
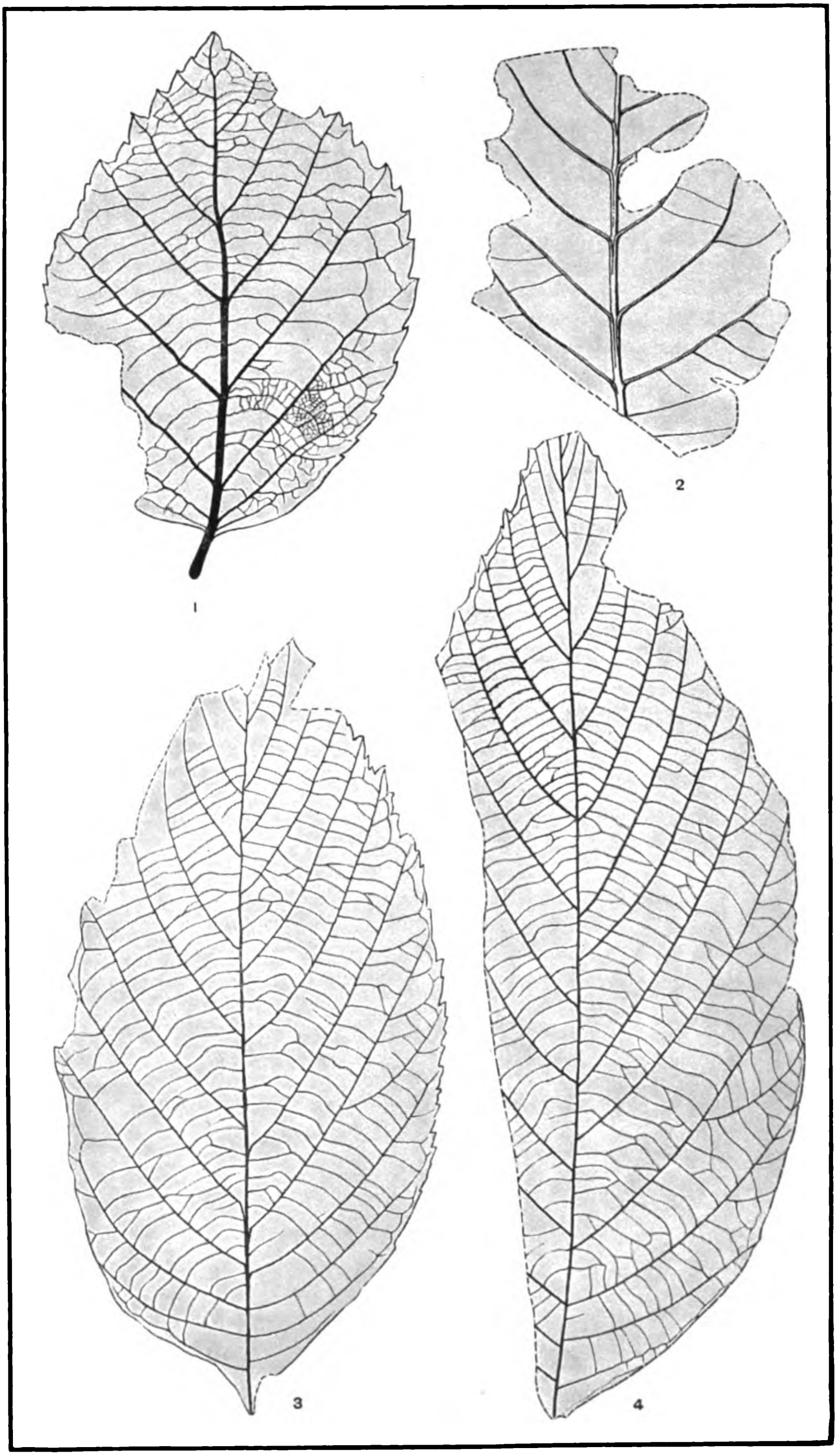


FOSSIL FLORA OF THE JOHN DAY BASIN.

PLATE V.

PLATE V.



FOSSIL FLORA OF THE JOHN DAY BASIN.

PLATE VI.

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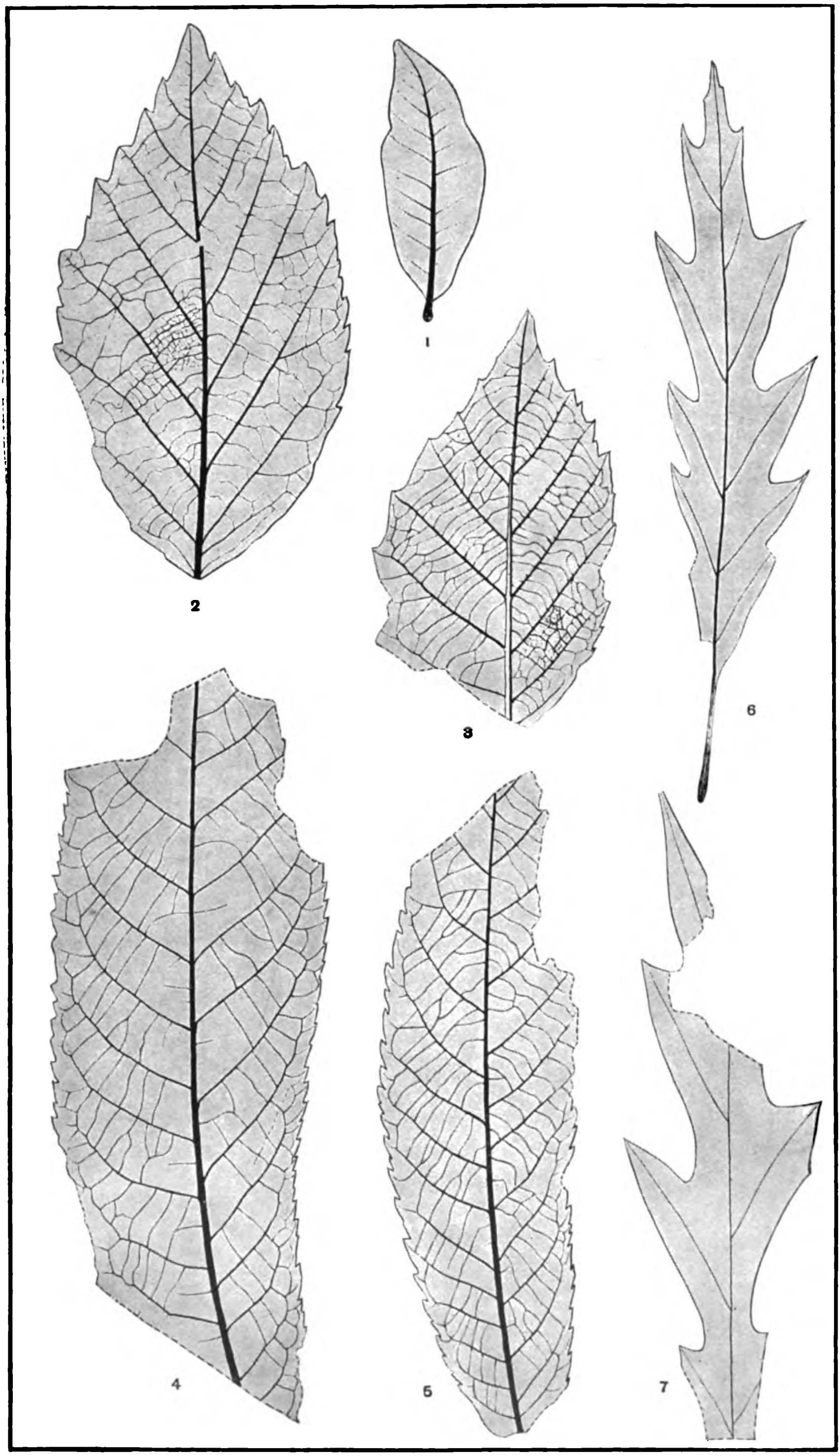

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PLATE VII.

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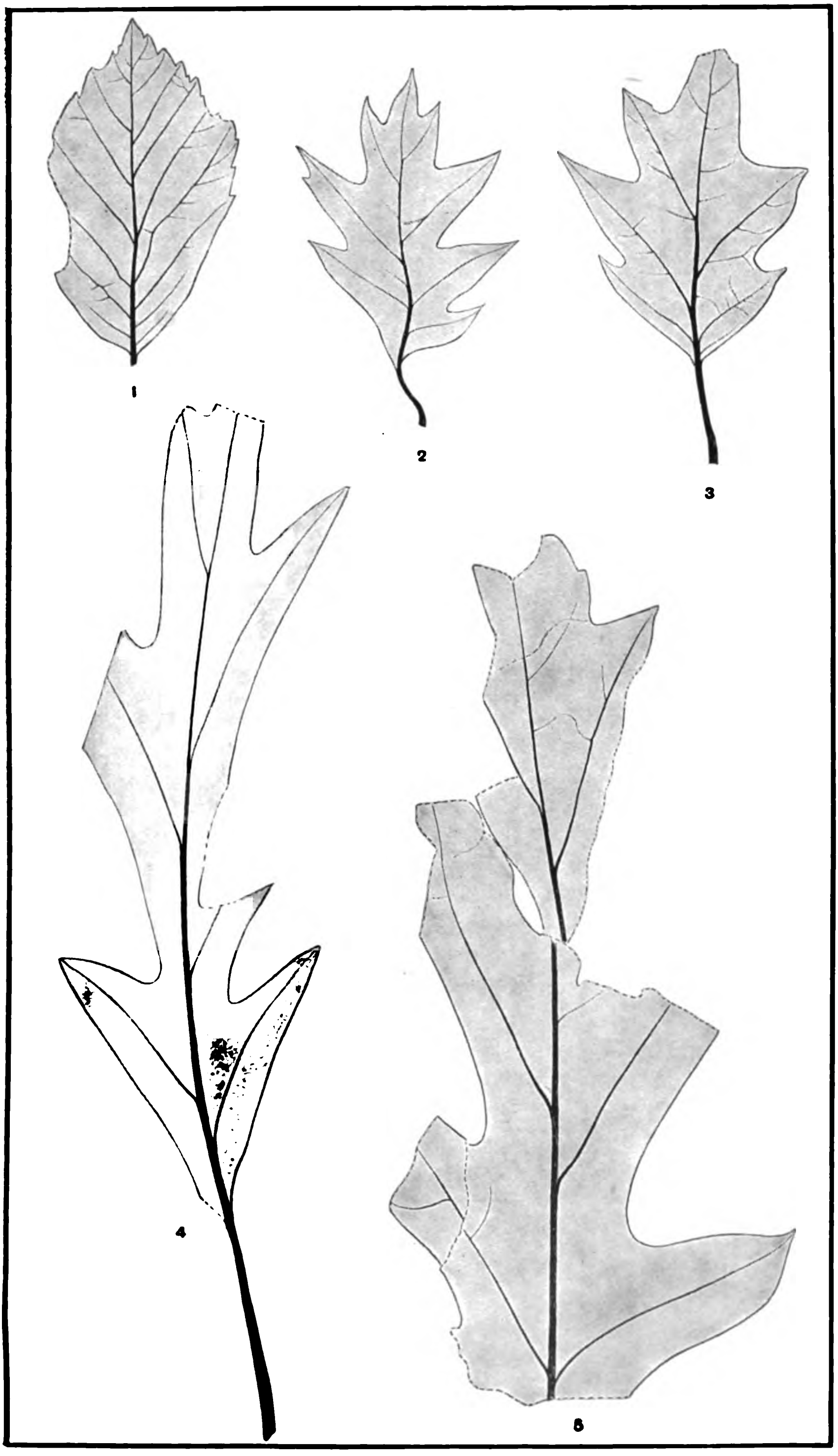

FOSSIL FLORA OF THE JOHN DAY BASIN.

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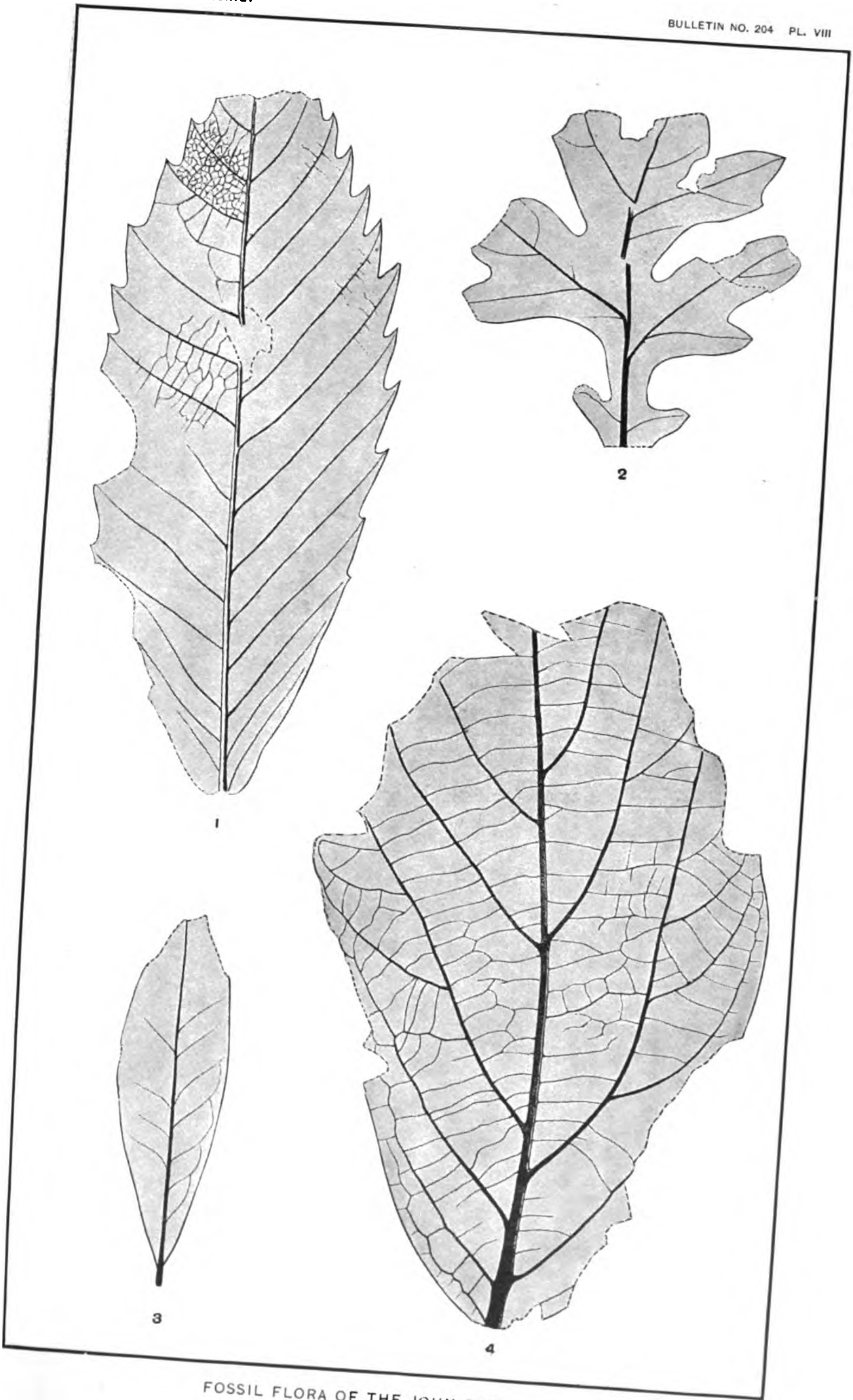

FOSSIL FLORA OF THE JOHN DAY BASIN.

PLATE IX.

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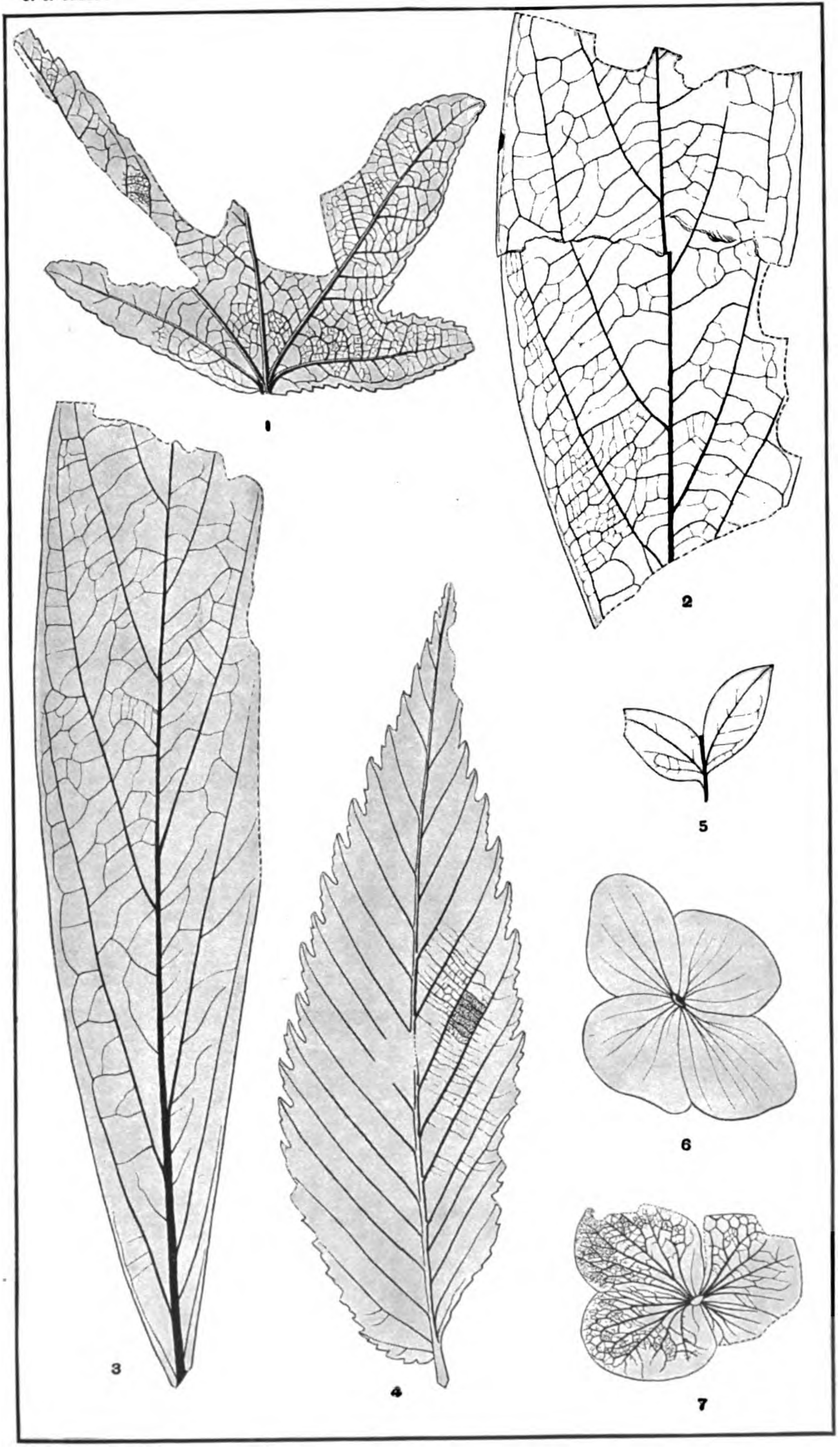

FOSSIL FLORA OF THE JOHN DAY BASIN.

PLATE X.

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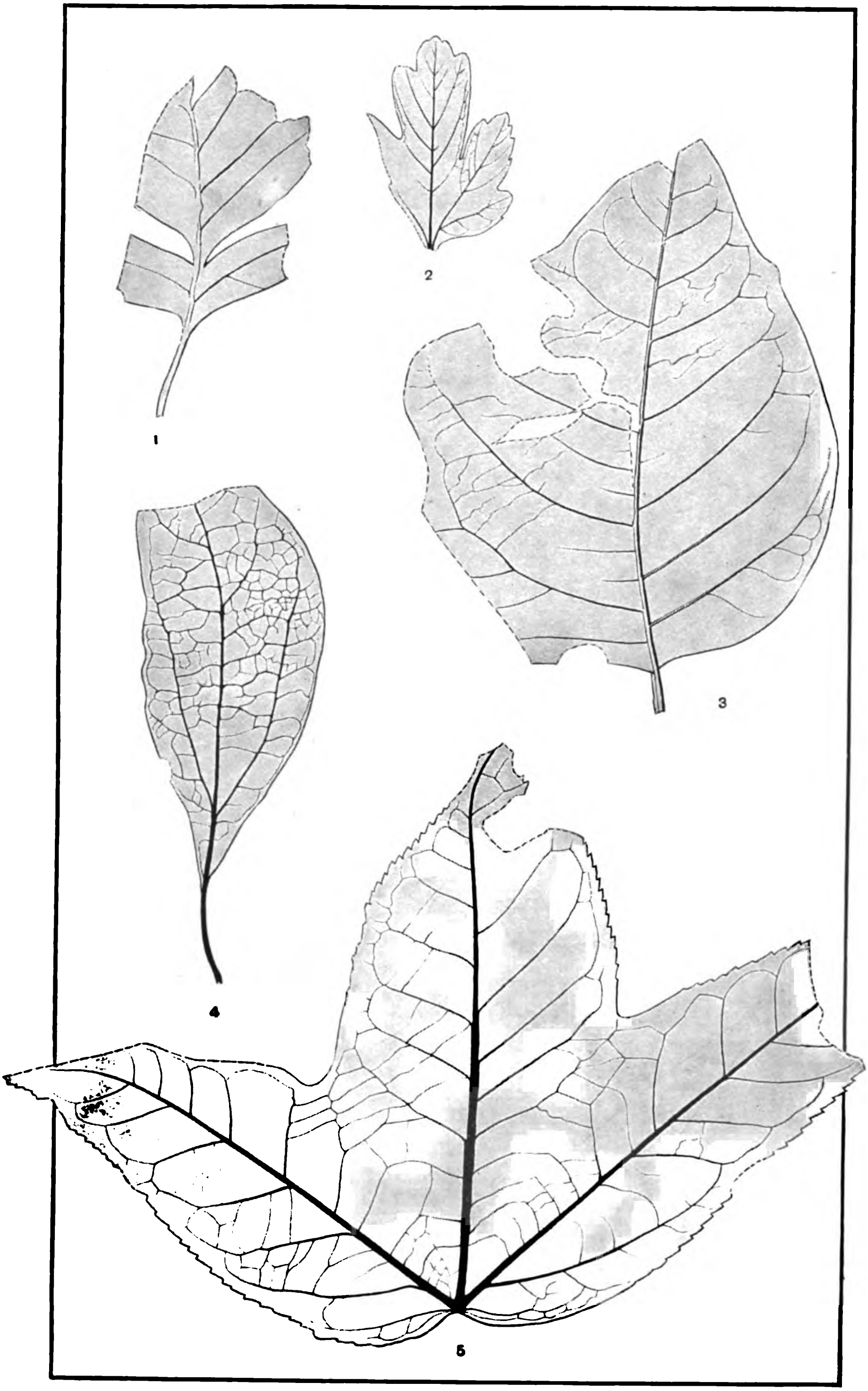

FOSSIL FLORA OF THE JOHN DAY BASIN.

PLATE XI.

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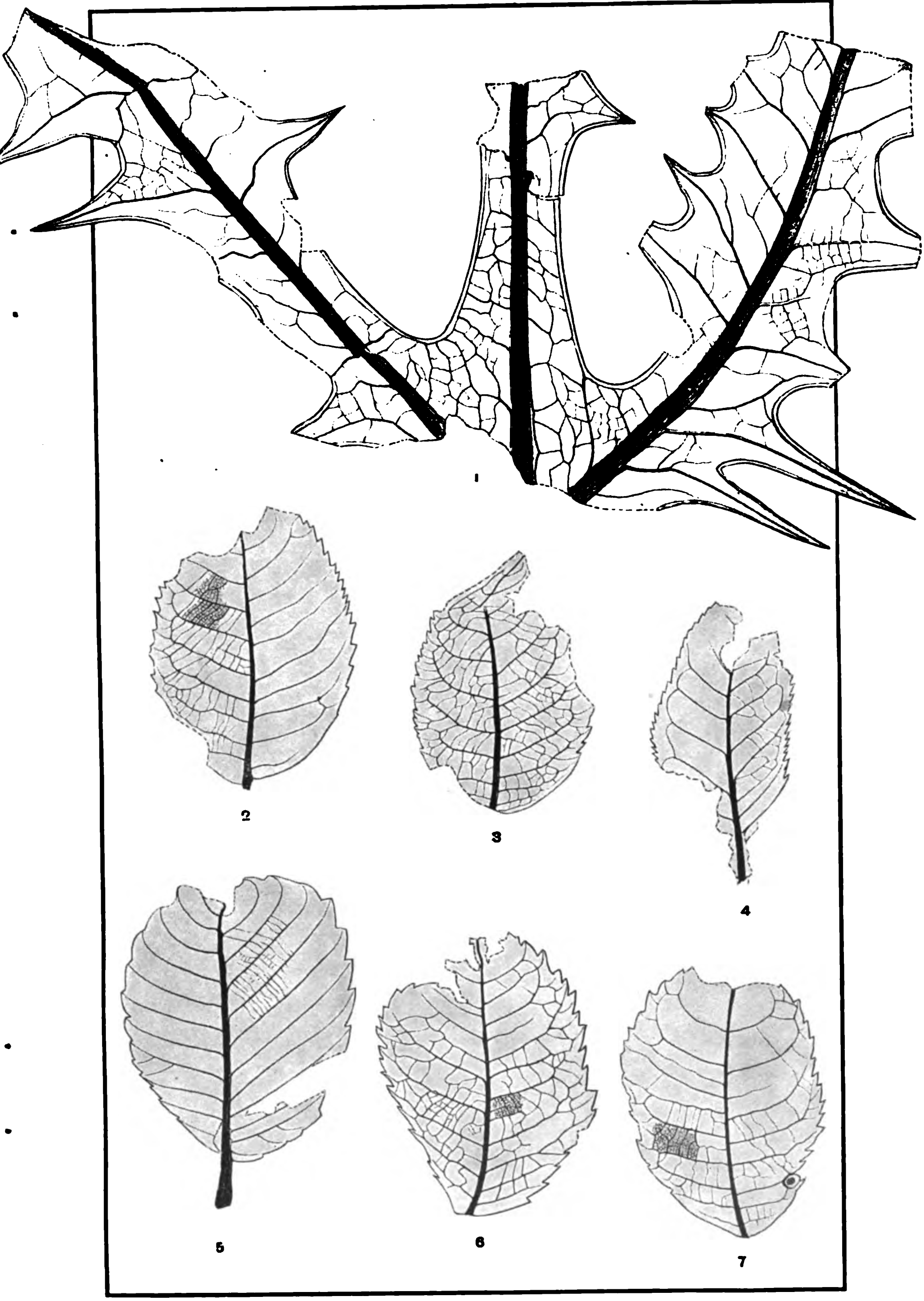

FOSSIL FLORA OF THE JOHN DAY BASIN.

PLATE XII.

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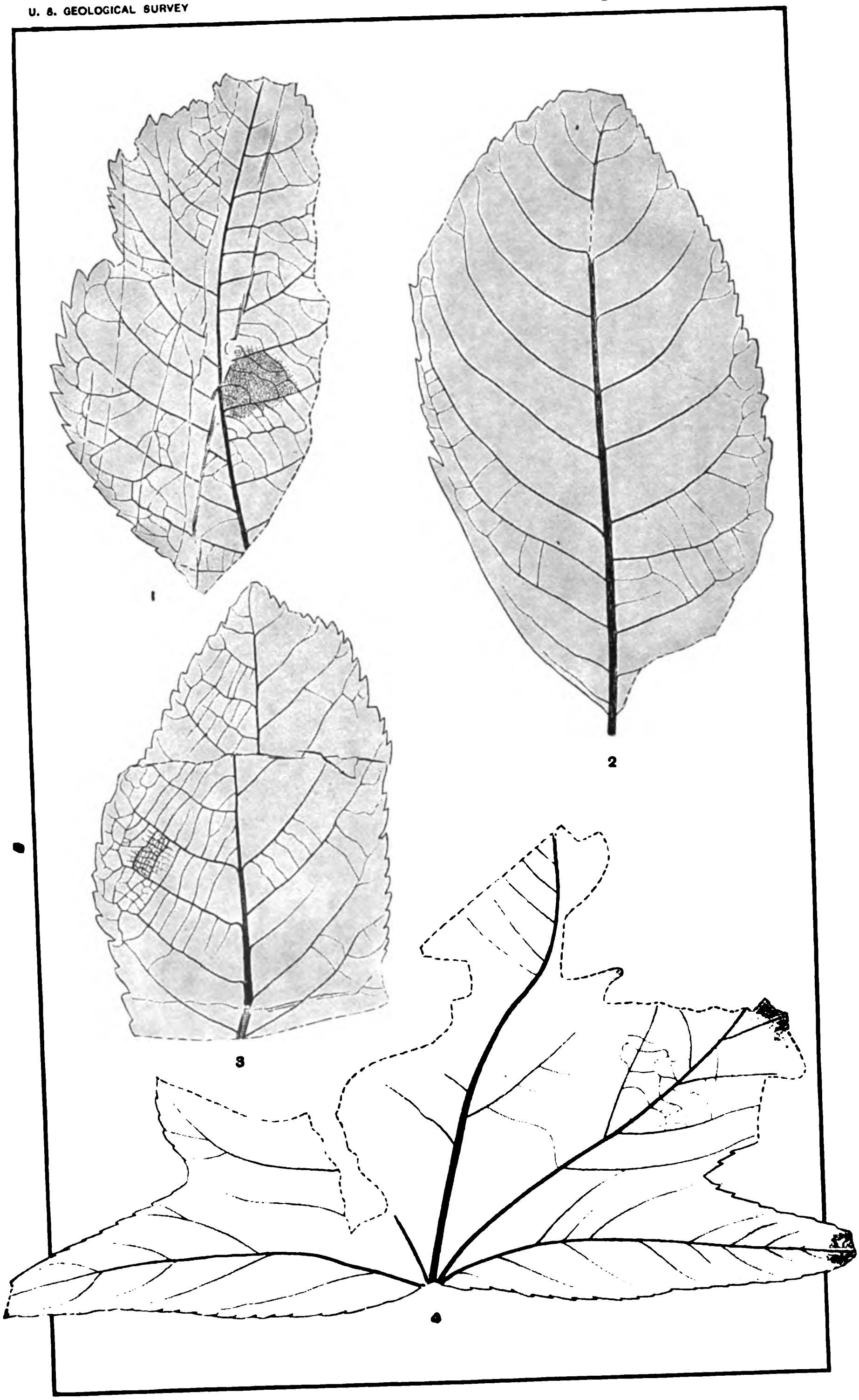

FOSSIL FLORA OF THE JOHN DAY BASIN.

PLATE XIII.

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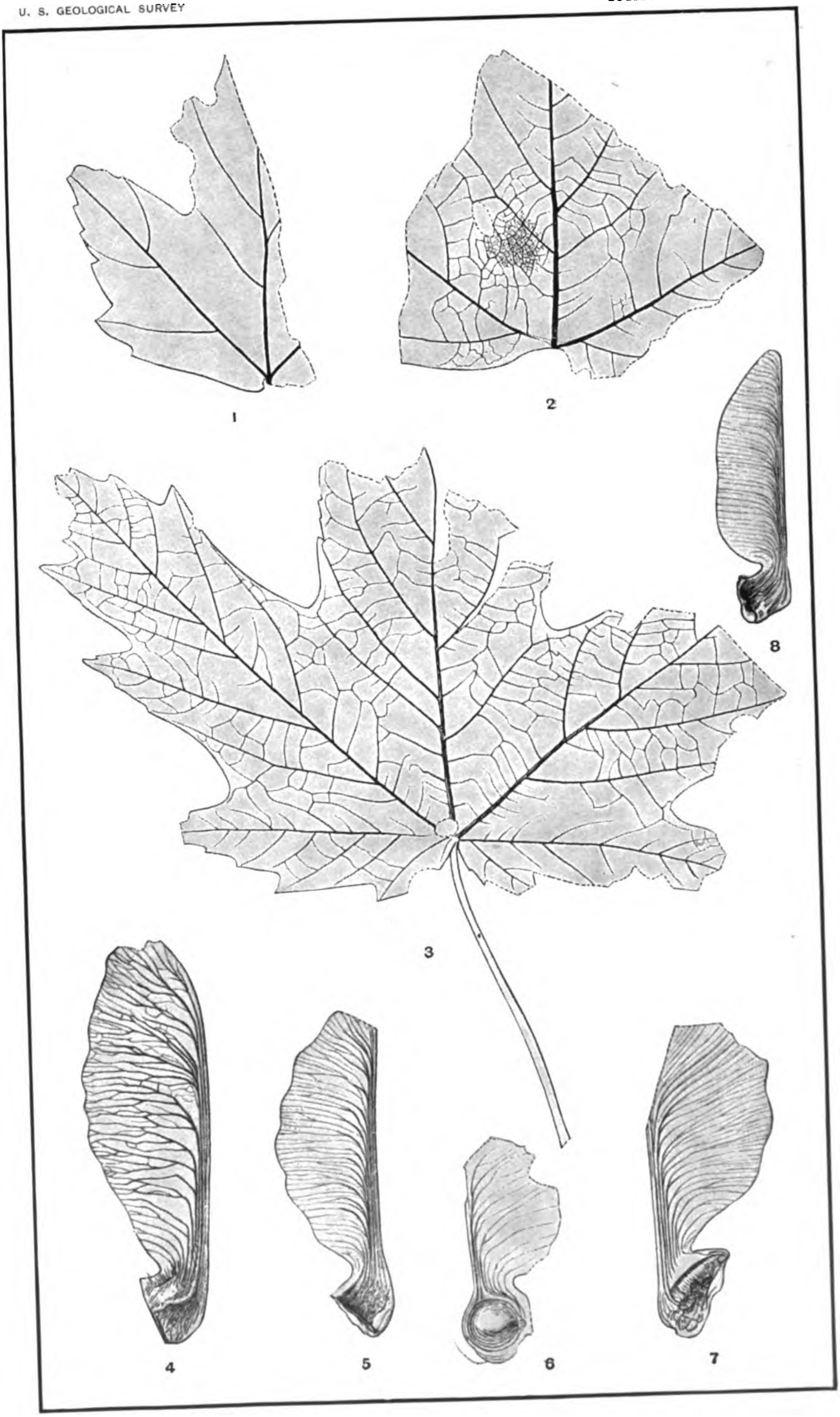

FOSSIL FLORA OF THE JOHN DAY BASIN.

PLATE XIV.

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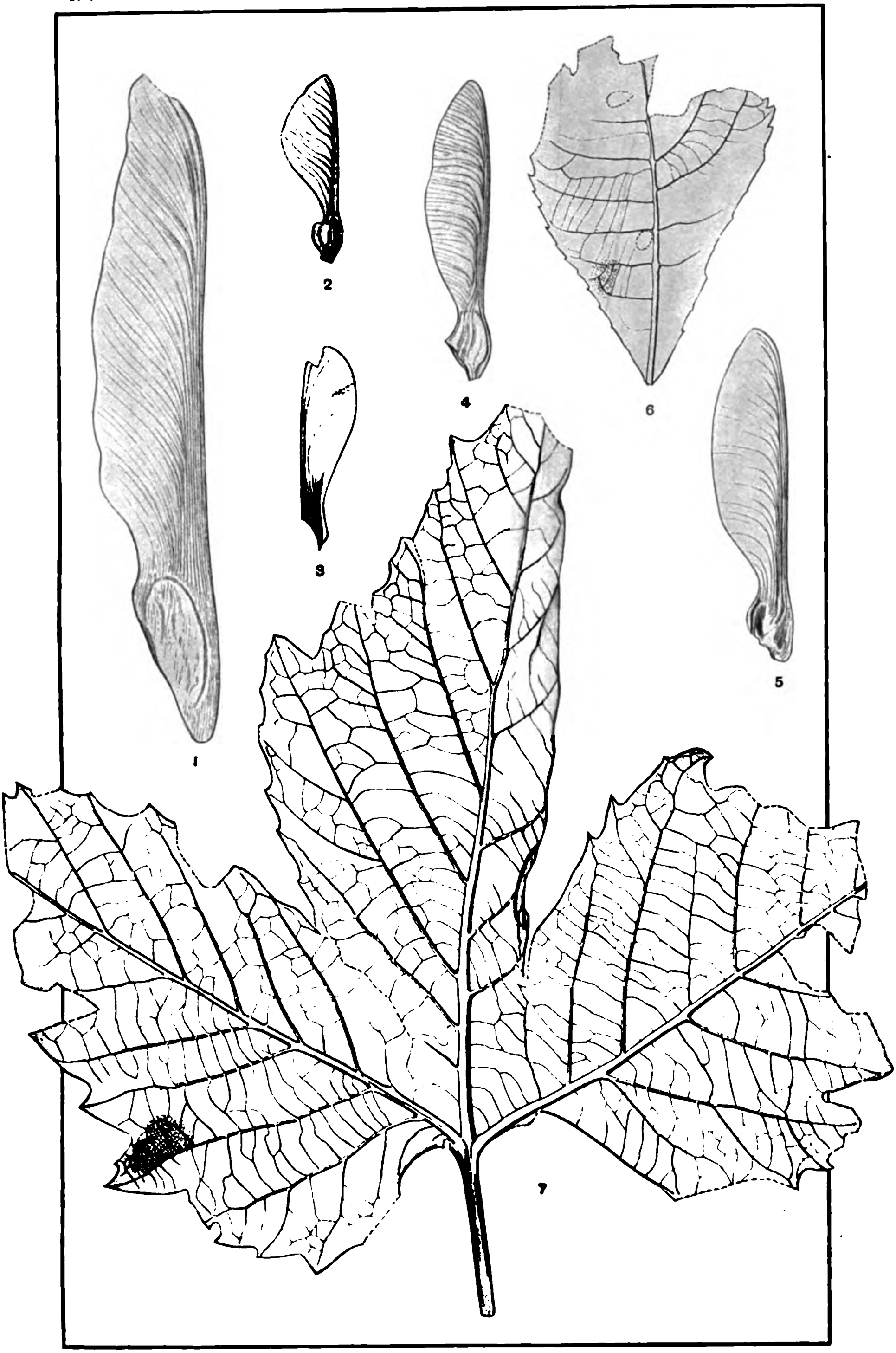

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PLATE XV.

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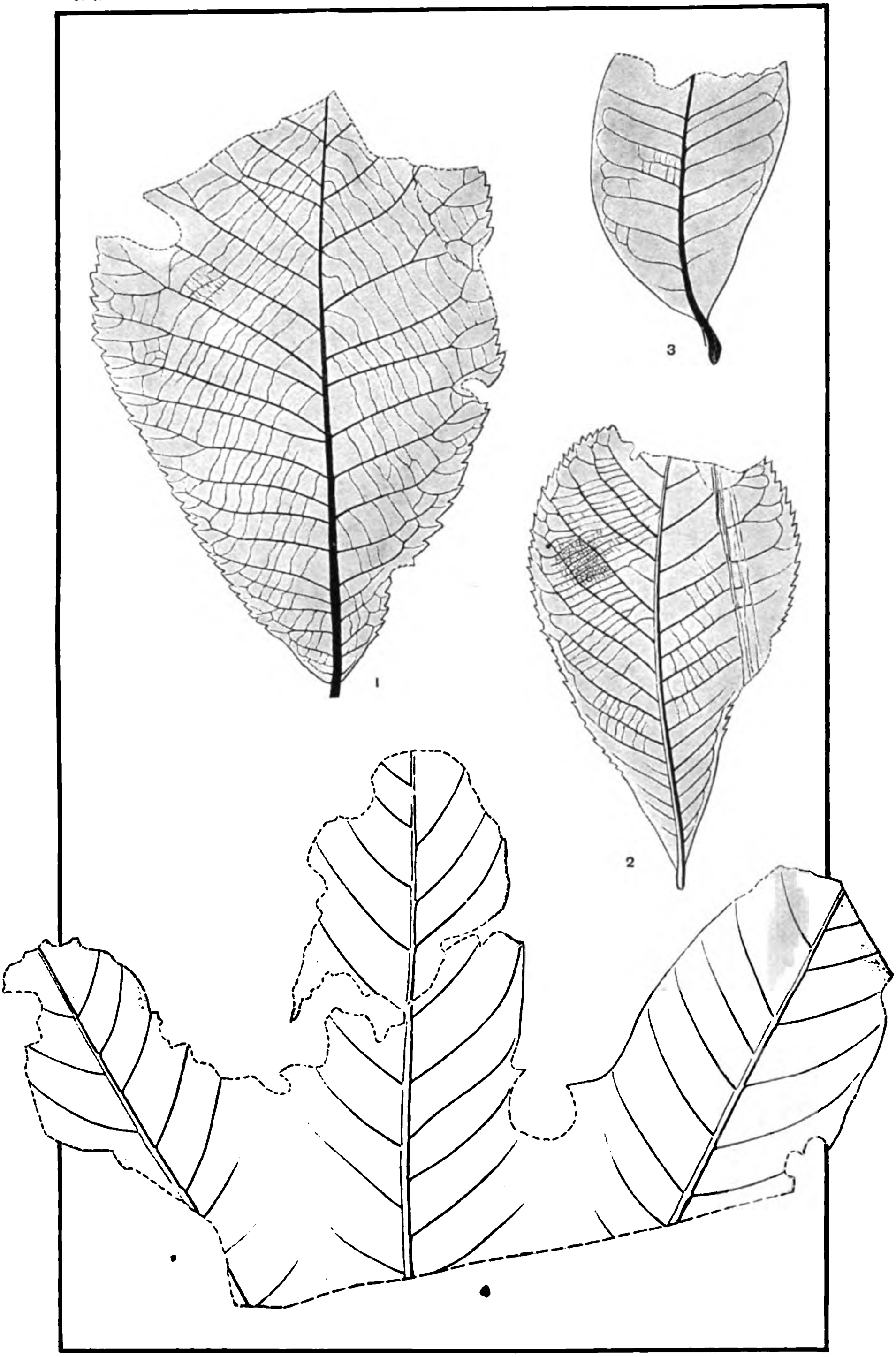

FOSSIL FLORA OF THE JOHN DAY BASIN.

PLATE XVI.

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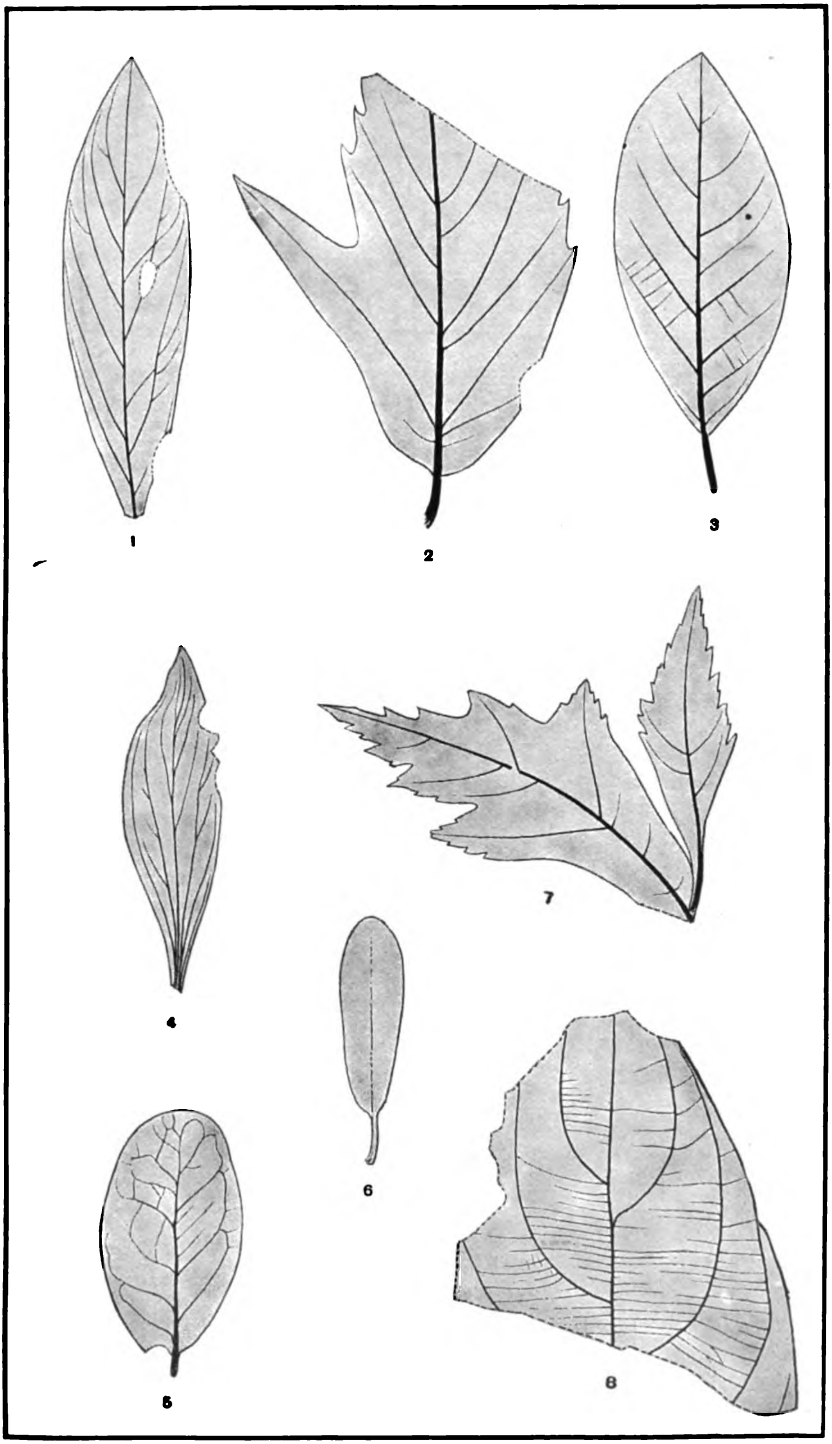

FOSSIL FLORA OF THE JOHN DAY BASIN.

PLATE XVII.

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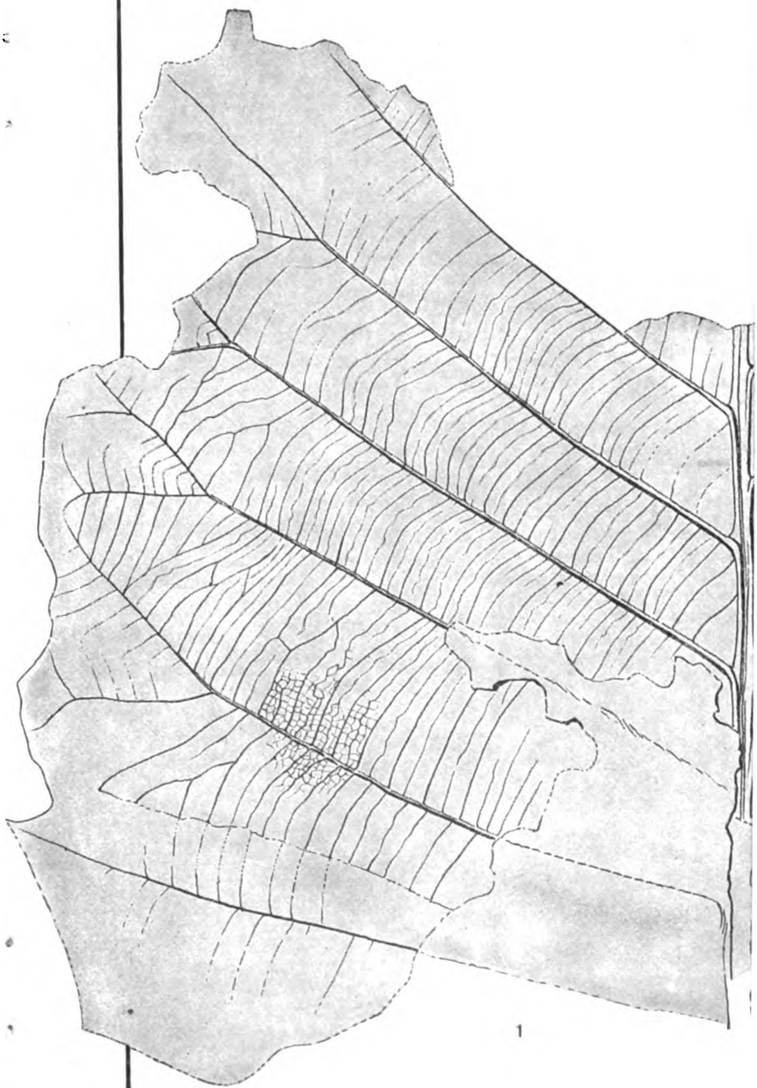

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FOSSIL FLORA OF THE JOHN DAY BASIN.

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[Heavy-faced figures refer to pages on which descriptions are given. Synonyms are in italic.]

O

PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY

[Bulletin No. 204.]

The serial publications of the United States Geological Survey consist of (1) Annual Reports, (2) Monographs, (3) Professional Papers, (4) Bulletins, (5) Mineral Resources, (6) Water-Supply and Irrigation Papers, (7) Topographic Atlas of United States—folios and separate sheets thereof, (8) Geologic Atlas of United States—folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists may be had on application.

The Bulletins, Professional Papers, and Water-Supply Papers treat of a variety of subjects, and the total number issued is large. They have therefore been classified into the following series: A, Economic geology; B, Descriptive geology; C, Systematic geology and paleontology; D, Petrography and mineralogy; E, Chemistry and physics; F, Geography; G, Miscellaneous; H, Forestry; I, Irrigation; J, Water storage; K, Pumping water; L, Quality of water; M, Methods of hydrographic investigations; N, Water power; O, Underground waters; P, Hydrographic progress reports. This bulletin is the fifty-eighth number in Series C, the complete list of which follows (all are bulletins thus far):

SERIES C, SYSTEMATIC GEOLOGY AND PALEONTOLOGY.

3. Fossil faunas of Upper Devonian, along the meridian 76° 30′, from Tompkins County, New York, to Bradford County, Pennsylvania, by Henry S. Williams. 1884. 36 pp.

4. Mesozoic fossils, by Charles A. White. 1884. 36 pp., 9 pls.

10. Cambrian faunas of North America. Preliminary studies, by C. D. Walcott. 1884. 74 pp., 10 pls.

11. Quaternary and recent mollusca of the Great Basin, with descriptions of new forms, by R. Ellsworth Call. Introduced by a sketch of the Quaternary lakes of the Great Basin, by G. K. Gilbert. 1884. 66 pp., 6 pls.

15. Mesozoic and Cenozoic paleontology of California, by C. A. White. 1885. 33 pp.

16. Higher Devonian faunas of Ontario County, New York, by John M. Clarke. 1885. 86 pp., 3 pls.

18. Marine Eocene, fresh-water Miocene, and other fossil mollusca of western North America, by Charles A. White. 1885. 26 pp., 3 pls.

19. Notes on the stratigraphy of California, by G. F. Becker. 1885. 28 pp. (Exhausted.)

22. New Cretaceous fossils from California, by C. A. White. 1885. 25 pp., 5 pls.

24. List of marine mollusca, comprising the Quaternary fossils and Recent forms from American localities between Cape Hatteras and Cape Roque, including the ermudas, by W. H. Dall. 1885. 336 pp.

29. Fresh-water invertebrates of the North American Jurassic, by C. A. White. 41 pp., 4 pls.

30. Second contribution to the studies on the Cambrian faunas of North America, by C. D. Walcott. 1886. 369 pp., 33 pls.

31. Systematic review of our present knowledge of fossil insects, including myriapods and arachnids, by S. H. Scudder. 1886. 128 pp.

34. Relation of the Laramie molluscan fauna to that of the succeeding fresh-water Eocene and other groups, by C. A. White. 1886. 54 pp., 5 pls.

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71. Index to known fossil insects of the world, including myriapods and arachnids, by S. H. Scudder. 1891. 744 pp.

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81. Correlation papers—Cambrian, by C. D. Walcott. 1891. 447 pp., 3 pls. (Exhausted.)

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DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., February 3, 1902.

SIR: The accompanying paper by Dr. George B. Shattuck on the Mollusca of the Buda limestone, with an appendix by Mr. T. Wayland Vaughan on the Anthozoa of the same horizon, records all that is known of the fauna of a limited formation constituting the highest member of the Comanche series in Texas. I recommend its publication as a bulletin.

Very respectfully,

T. W. STANTON,
Paleontologist.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

THE MOLLUSCA OF THE BUDA LIMESTONE.

By George Burbank Shattuck.

PREFATORY NOTE.

During the winter of 1893–94 the Johns Hopkins University came into possession of a valuable collection of fossils which Mr. Robert T. Hill, of the United States Geological Survey, had assembled during many years of geologic study in Texas. Among the various faunas represented in this collection the fauna of the Buda limestone—so called because of its typical development at Buda, Tex.—presented an interesting problem to the author. Through the courtesy of Hon. C. D. Walcott, Director of the United States Geological Survey, and Mr. Hill the author was enabled to accompany the latter during a portion of the field season of 1894, in order to collect from the Buda limestone in the vicinity of Austin, Tex.

The following contribution, which is the result of a study of the Buda limestone fauna, has been prepared under the supervision of Prof. William B. Clark, to whom the author here expresses his deep obligation. He also extends his acknowledgments to Dr. T. W. Stanton, of the United States Geological Survey, for many valuable suggestions and for the use of type specimens, and to Hon. C. D. Walcott and Mr. Robert T. Hill, through whose courtesy the author was enabled to undertake this work. The late Prof. Alpheus Hyatt was consulted regarding the ammonites.

Mr. T. Wayland Vaughan, of the United States Geological Survey, has prepared the concluding section on the corals.

HISTORICAL REVIEW.

The Buda limestone, although possessing considerable thickness (40 to 80 feet) and recording important events which took place at the close of the Lower Cretaceous, is so concealed beneath younger beds that it remained for a long time unrecognized by the various geologists who worked in Texas. It was not until the year 1889 that Mr. Robert T. Hill described it and designated it by the name "Vola limestone," so called on account of a large and beautiful *Vola* which was present in considerable numbers in the formation.[a]

In a second article[b] Mr. Hill gave a section in which he assigned

[a] A portion of the geologic story of the Colorado River of Texas: Am. Geologist, May, 1889, p. 8.
[b] Annot. check list of the Cretaceous invertebrate fossils of Texas: Bull. Geol. Surv. Texas, No. 4, p. xiv.

the Vola limestone—this time referring to it as the "Shoal Creek limestone," because of its typical exposure in the limestone bluffs along Shoal Creek at Austin, Tex.—to a place at the top of the Washita division of the Comanche series; that is to say, the topmost bed of the Lower Cretaceous, and correlated it with the *Ostrea quadriplicata* beds of Denison. In April of the same year Mr. Hill expressed the opinion[a] that the Buda limestone—here speaking of it as the Vola or red chalk limestone, because of the red blotches found in it—belonged to the Washita division, a series of strata deposited by continuous sedimentation during the first profound marine subsidence, that it was underlain by the *Exogyra arietina* clays and overlain by the Denison beds, that its fossils consisted of the characteristic *Vola quinquecostata* Sow. and an undescribed fauna, and that the material was a massive lime bed with oxidizing iron, the total thickness being 50 feet.

Toward the close of the year Mr. Hill published a section[b] of the Lower Cretaceous in which he showed that it belonged to the Lower or Grand Prairie formation (Comanche series), with the Shoal Creek or Vola limestone at the top, possessing a thickness of 75 feet and underlain by the *Exogyra arietina* clays. Nothing further was published regarding the Shoal Creek limestone until 1893, when Profs. W. B. Clark[c] and F. W. Cragin[d] described certain of its fossils.

The following year Mr. Hill again published a description[e] of the Shoal Creek limestone, in which he pointed out the relations of the underlying and overlying beds in more detail, and indicated with a section the gradual thinning of the limestone from Del Rio through Austin to Waco, where it disappeared. The red-colored blotches in the limestone, he concluded, were due to oxidation of the iron in minute glauconite grains. He also announced the discovery of foraminiferal remains and gave a list of fossils.

In 1897 Dr. T. W. Stanton published a comparative study of the Lower Cretaceous formations,[f] in which he discussed at length the features of the Comanche series and pointed out its relations to the other Lower Cretaceous formations. He also mentioned the Shoal Creek limestone and gave a summary of Hill's classification indicating its relative position.

The next publication referring to the Shoal Creek limestone appeared in 1898 as a bulletin of the United States Geological Survey, under

[a] Events in North American Cretaceous history, etc.: Am. Jour. Sci., April, 1889, 3d series, Vol. XXXVII, p. 290.

[b] Relation of the uppermost Cretaceous beds of the eastern and southern United States: Am. Jour. Sci., Dec. 1889, Vol. XXXVIII, p. 470.

[c] Mesozoic Echinodermata of United States: Bull. U. S. Geol. Surv. No. 97, pp. 90-91, pl. XLIX, figs. 2, a-i.

[d] Cont. to Invert. Pal. of Texas Cret.: Fourth Ann. Rept. Geol. Surv. Texas.

[e] Geol. of parts of Texas, Ind. Ter., and Ark., etc.: Bull. Geol. Soc. America, vol. 5, pp. 317-321.

[f] A comparative study of the Lower Cretaceous formations and faunas of the United States: Jour. Geol., Vol. V, pp. 579-624.

the joint authorship of Messrs. Hill and Vaughan.[a] In this paper the classification of the gryphæas of the Texas region was discussed, species were described, and figures were given. The geographic and stratigraphic distribution was also shown, and the probable relationship and evolution of the various forms of *Gryphæa* occurring in the Texas region were indicated. Before the close of the year the same authors published another paper, discussing the relation of the geology in certain parts of Texas to the flow of underground water.[b] In this paper the Shoal Creek limestone was described and its relation to other strata in the Cretaceous series was pointed out.

The latest publication dealing with the Shoal Creek limestone is by Mr. Hill.[c] In this paper Hill substituted the name "Buda limestone" for "Shoal Creek limestone," and summarized the leading features of the formation.

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HILL, R. T. Geology of parts of Texas, Indian Territory, and Arkansas adjacent to Red River. Bull. Geol. Soc. America, vol. 5, 1894, pp. 317–321, pl. 13, and fig. 2.

[a] The Lower Cretaceous gryphæas of the Texas region: Bull. U. S. Geol. Surv. No. 151.

[b] Geology of the Edwards Plateau and Rio Grande Plain adjacent to Austin and San Antonio, Tex., with reference to the occurrence of underground water: Eighteenth Ann. Rept. U. S. Geol. Surv., Pt. II, pp. 193–316.

[c] Geology and geography of the Black and Grand prairies, Texas, etc.: Twenty-first Ann. Rept. U. S. Geol. Surv. (for 1899–1900), Pt. VII, 1901, pp. 288–290.

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HILL, R. T. Geography and geology of the Black and Grand prairies, Texas etc. Twenty-first Ann. Rept. U. S. Geol. Survey, Pt. VII, 1901.

GEOLOGY OF THE BUDA LIMESTONE.

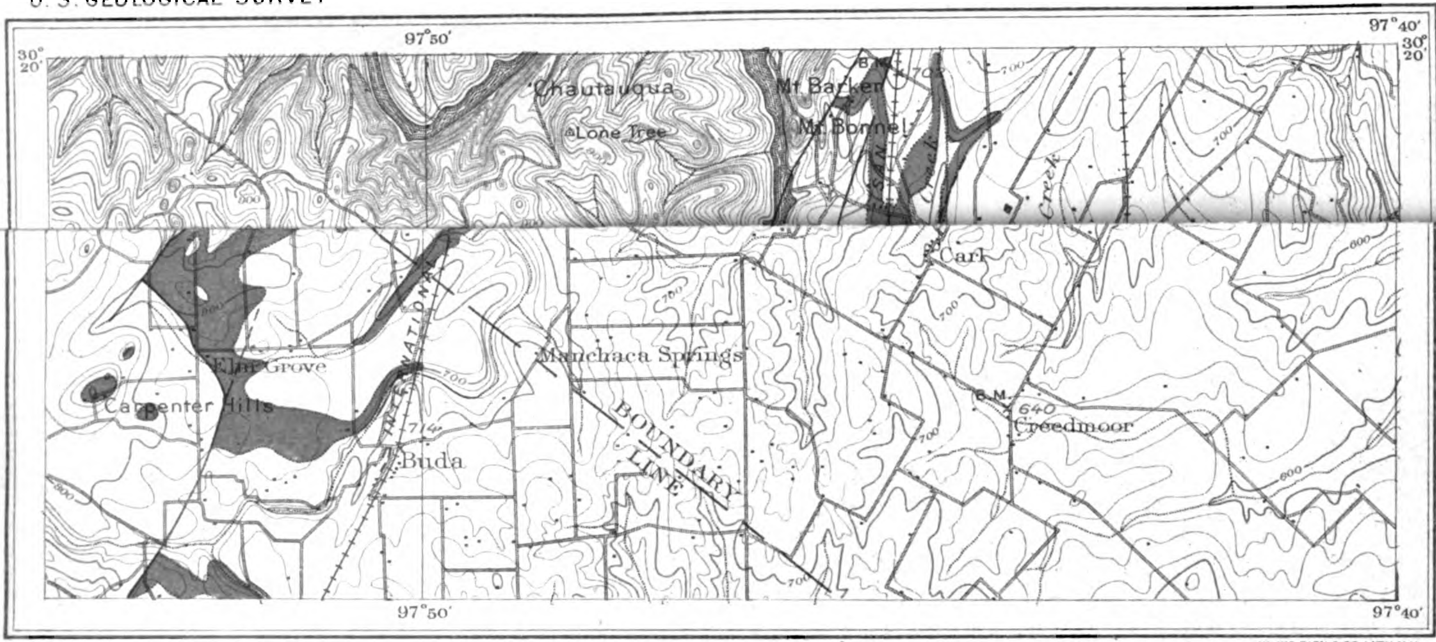
The work of the author while in Texas was confined to collecting from the Buda limestone near Austin, while the task of determining the geologic relations of that formation and mapping its areal extent has been done by Mr. R. T. Hill. The author is, therefore, unable to speak regarding the geology of the Buda limestone, except as that information has been published. The following statement is consequently derived entirely from the description by Mr. Hill, given in the Twenty-first Annual Report of the United States Geological Survey.

The Lower Cretaceous formations of Texas have been placed collectively in one group, called the Comanche series. The Comanche series is again divisible, beginning with the oldest, into the Trinity, Fredericksburg, and Washita divisions. The Washita division is in turn composed of several formations, which vary in number and extent from one locality to another. The city of Austin, Tex., is located in the midst of the region in which the Buda limestone is best developed. There it is found typically exposed in two localities, one along Shoal Creek, on the northeastern border of the city, and the other at Buda, about 14 miles southeast of the city, on the International and Great Northern Railway. In this region the Washita consists of three formations. These are, beginning with the oldest, Georgetown, Del Rio, and Buda. The Georgetown formation is composed principally of limestone; the Del Rio formation consists of an unctuous clay, and the Buda formation is also a limestone.

The Buda limestone first appears south of the Brazos River, where it is apparently the stratigraphic continuation of the Grayson marls, which occur north of the river. As the Buda limestone is traced southward from the Brazos it becomes more clearly defined. This formation was first named the Vola limestone, and later designated the Shoal Creek limestone, but recently it was found that that name was preempted and it is now known as the Buda limestone. It has been defined by Mr. Hill as follows:[a]

The Buda limestone may be defined as the uppermost of the three formations of the Washita division throughout southern Texas, where it is also the final bed of

[a] Twenty-first Ann. Rept. U. S. Geol. Survey, Pt. VII, 1901, p. 288.



Geology by R T Hill and T W Vaughan
Topography by
E M Bannerman, J W B...

MAP OF THE REGION NEAR AUSTIN, TEXAS.

Showing exposures of Buda Limestone

Scale

1 ½ 0 1 2 3 4 5 miles

the Lower Cretaceous, occupying the same position in the southern section relative to the series as do the Grayson marls of the northern section, the one probably being the seaward extension of the other.

The Buda limestone is best exposed in the steep cliffs of Shoal Creek, in the city of Austin, in the bluffs of Bouldin Creek, and on the outer margins of Barton Creek Valley south of Austin. It is also found well developed at Buda, 14 miles southwest of the city. In this region the limestone is stratified in layers varying in thickness from 2 to 6 feet. As the strata vary somewhat in hardness and power to withstand erosion, they are affected differently by the elements. Certain of them preserve a smooth surface, others exhibit a shattered and rubbly appearance, and still others break down into a fine powder. These last are apt to give place to recesses or caverns which retreat beneath overhanging bluffs of more obdurate material. The limestone when first fractured possesses a light yellowish drab ground color, specked with spots about the size of a coriander seed, but on weathering these little specks oxidize to a yellowish or red color, and cause the surface to appear as if it had been burned. On microscopic examination it has been found that these little spots are fossil foraminifera filled with a mineral substance, possibly glauconite, which on weathering oxidizes to red. The limestone as a whole appears to be made up more largely of foraminifera than any other in the entire Comanche series.

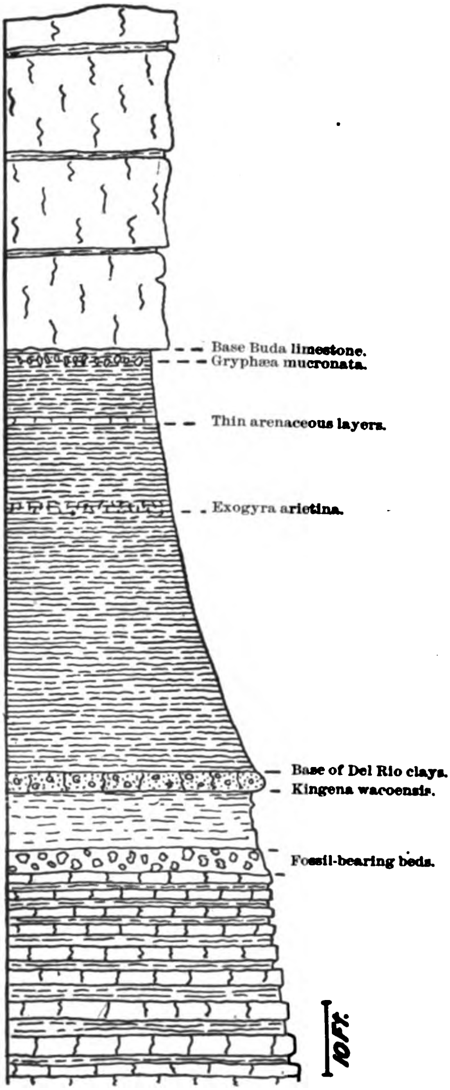


FIG. 1.—Section of Buda limestone, Del Rio clays, and Fort Worth limestone at Austin, Tex.

The outcrop of the Buda limestone is not extensive. It is developed in a narrow band between the Del Rio clay below and the Eagle Ford

formation above, extending from the Brazos to the Colorado and southward to the Rio Grande. Throughout this region it is found exposed in many places. In the region of Austin the formation is nearly 80 feet thick, and it increases in thickness southward, attaining on the Nueces 100 feet. Northward from Austin it decreases in thickness at the rate of about 2 feet a mile, until at Round Rock it is only 20 feet thick, on San Gabriel River 10 feet, at Moody about 5 feet, and at Bosqueville, on the Brazos River, it is represented by a bed of limestone only 1 foot in thickness. North of the Brazos, as stated above, it merges with the Grayson marl and is no longer distinguishable as a limestone stratum.

Although the Buda limestone is rich in fossils the remains are poorly preserved and are often represented only by casts or molds. Many of these forms are also found in earlier members of the Comanche series. The following is a list of the fossils of the Buda limestone which have been identified and described:

LIST OF SPECIES IN BUDA LIMESTONE.

FORAMINIFERA.

Rotalia sp.
Textularia sp.

ECHINODERMATA.

Hemiaster calvini Clark.

PELECYPODA.

Pecten roemeri (Hill).
Pecten quinquecostatus? Sowerby.
Pecten duplicicosta Roemer.
Pecten texanus Roemer.
Lima shumardi sp. nov.
Lima wacoensis Roemer.
Lima sp.
Gervilliopsis invaginata? (White).
Inoceramus sp.
Pinna sp.
Spondylus sp.
Ostrea sp.
Alectryonia sp.
Gryphæa mucronata Gabb.
Exogyra clarki sp. nov.
Modiola? sp.
Cucullæa sp.
Trigonia emoryi Conrad.
Ptychomya ragsdalei (Cragin).
Cardium (Granocardium) budaense sp. nov.
Cardium (Protocardia) texanum (Conrad).
Cardium (Protocardia) vaughani sp. nov.
Pachymya austinensis? Shumard.
Isocardia medialis (Conrad).
Pholadomya roemeri sp. nov.
Homomya austinensis sp. nov.
Homomya vulgaris sp. nov.
Anatina austinensis sp. nov.
Anatina texana sp. nov.

GASTEROPODA.

Patella sp.
Pleurotomaria stantoni sp. nov.
Trochus sp.
Turritella budaensis sp. nov.
Cerithium? texanum sp. nov.
Harpagodes shumardi (Hill).
Cypræa sp.
Fusus texanus sp. nov.
Fusus sp.

CEPHALOPODA.

Nautilus texanus Shumard.
Nautilus hilli sp. nov.
Barroisiceras texanum sp. nov.
Barroisiceras hyatti sp. nov.

ANTHOZOA.

Parasmilia texana, sp. nov.
Trochosmilia (?) sp. indet.
Orbicella (?) texana sp. nov.
Leptophyllia sp. (No. 1).
Leptophyllia sp. (No. 2).

DESCRIPTIONS OF SPECIES.

MOLLUSCA.

PELECYPODA.

PECTINIDÆ.

Genus PECTEN Müller.

PECTEN ROEMERI (Hill).

Pls. II–IV; Pl. V, fig. 1.

Pecten (Vola?) roemeri Hill, 1889, Pal. of the Cret. Formations of Texas, Pt. 1, Pl. I.

Pecten (Vola) roemeri Hill, 1889, Annot. Check List Cret. Invert. Fossils of Texas: Bull Geol. Surv. Texas No. 4, p. 8.

Dimensions.—Length, 15 cm.; breadth, 14 cm.

Description.—Shell large, compressed, thick; margin scalloped, concavities of one valve receiving the convexities of the other; sub-octahedral; equilateral, unequivalved; right valve subglobose, left valve slightly convex; hinge line straight, two-thirds length of shell, medial, symmetrical, reflected toward left valve; umbos opposite, medial; that of the right valve prominent, that of the left depressed; ears equal, produced, conspicuous. decorated with radiating costæ. Surface decorations consist of six major radiating ribs, including between them groups of two or three minor costæ. In the region of the wings the costæ are of uniform strength. Concentric undulations are also prominent and lines of growth well marked.

This *Vola* is very abundant in the Buda limestone, and suggested the name Vola limestone, by which this formation was originally known. Mr. Hill, in discussing the Buda ("Shoal Creek") limestone in an early paper,[a] referred to this form as *Vola quinquecostata* Sow.

Locality.—Shoal Creek, Austin, Tex.; Onion Creek, Buda, Tex.

This form has never been reported from any other formation.

Collections.—Johns Hopkins University;[b] United States National Museum.

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[a] Events in North American Cretaceous history, etc.: Am. Jour. Sci., April, 1889, 3d series, Vol. XXXVII, p. 290.

[b] Concerning the specimens described in this paper, it may here be said that Mr. Hill collected those in possession of the Johns Hopkins University, while those in possession of the United States National Museum were in great measure collected by the writer for the United States Geological Survey.

PECTEN QUINQUECOSTATUS? (Sowerby).

Pl. V, figs. 2–4.

Pecten quinquecostatus Sowerby, 1814, Min. Conch.. Vol I, p. 121, tab. 56, figs. 4–8.
Pecten quadricostatus Sowerby, 1814, Min. Conch., Vol. I, p. 121, tab. 56, figs. 1, 2.
Janira quinquecostata d'Orb., 1846, Pal. Franc. Terr. Crét., Vol. III, p. 632, pl. 441, figs. 1–5.
Janira quadricostata d'Orb., 1846, Pal. Franc. Terr. Crét., Vol. III, p. 644, pl. 447, figs. 1–7.

Dimensions.—Length, 35 mm.; breadth, 4 cm.

Description.—Shell medium to small; outline sinuous; right valve ventricose, with prominently elevated umbo; ears absent. The surface decorations consist of five prominent, radiating, trifid ribs, of which the middle individual is more elevated and conspicuous than either of the lateral members. Each of the spaces between the five trifid ribs is occupied by two equal, less prominent ribs, which also extend from the umbo to the margin. All the specimens of left valves in the collection belong to immature individuals. They are slightly concave, bear six major radiating ribs, on the curved surface of which are three or four minor costæ. The depressions between the major ribs are broad and contain two costæ each.

The specific position of this shell has been subject to considerable dispute, and a variety of opinions have been expressed, by those who have described it, in regard to its correct systematic position. This confusion seems to be due to a variation in the number and strength of the minor costæ. In determining this species the author inclines to refer it to *Pecten quinquecostatus* rather than to make it a distinct species. It is a common form in the Buda limestone.

Locality.—Shoal Creek, Austin, Tex.; Onion Creek, Buda, Tex.

This species has been reported from the Washita limestone, the Edwards limestone, and the Upper Cretaceous beds of New Jersey.

Collections.—Johns Hopkins University; United States National Museum.

PECTEN DUPLICICOSTA (?) Roemer.

Pl. V, fig. 5.

Pecten duplicicosta Roemer, 1849, Texas etc., p. 398.
Pecten duplicicosta Roemer, 1852, Kreid. von Texas, p. 65, Pl. VIII. fig. 2, a, b.

Description.—Shell medium, polygonal; left valve very globose. Decorations consist of six ridges radiating from the umbo to the angles of the margin. These ridges are each traversed by three longitudinal ribs. Each of the spaces between the ridges is occupied by three conspicuous costæ.

Roemer described his type specimen as having all the secondary costæ equally developed, while in the specimen described here the ribs traversing the ridges are not so prominent as the costæ located in the interspaces; moreover, the form here described is not so wide

in proportion to its length as that figured and described by Roemer, but it appears to have suffered compression.

Locality.—Shoal Creek, Austin, Tex.; Onion Creek, Buda, Tex.

This species occurs in the Edwards limestone.

Collection.—United States National Museum.

Pecten texanus Roemer.

Pl. V, figs. 6–8.

Pecten æquicostatus Roemer, 1849, Texas etc., p. 398.
Pecten texanus Roemer, 1852, Kreid. von Texas, p. 65, Pl. VIII, fig. 3, a, b.
Neithea texana Conrad, 1857, Rept. U. S. Mex. Bound. Surv., Vol. I, Pt. II, p. 151, Pl. V, fig. 2, a, b.
Pecten texanus Gabb, 1861, Notes on Cret. Fossils, etc.: Proc. Acad. Sci., Phil., p. 365.

Dimensions.—Length, 31 mm.; breadth, 35 mm.

Description.—Shell medium, triangular; margin polygonal; left valve globose; umbo curved over hinge area; ears conspicuous; hinge line straight. Decorations consist of minute concentric striæ and six prominent rounded ribs, radiating from the umbo to the angles of the margin; the broad spaces between them are each occupied by two equal, but subordinate, rounded costæ, whose width is greater than that of the grooves separating them.

A young individual has the following appearance: Shell small; margin sinuous; outline triangular; left valve globose; umbo produced. Decorations consist of eighteen radiating costæ, of which every third costa is more elevated than the two intermediate individuals. The right valve is slightly concave and decorated with twenty narrow, radiating ribs, whose disposition is regular.

In the adult specimens figured by both Conrad and Roemer the ribs are described as flattened. This, however, is not the case in these specimens.

This appears to be a rare form in the Buda limestone.

Locality.—Shoal Creek, Austin, Tex.; Onion Creek, Buda, Tex.; Fish Pond Point, Texas; Bartons Creek, Travis County, Tex.

This species is common throughout the Washita division.

Collection.—United States National Museum.

LIMIDÆ.

Genus LIMA Bruguiére.

Lima shumardi sp. nov.

Pl. V, fig. 11.

Dimensions.—Length, 25 mm.; breadth, 26 mm.

Description.—Shell small, thin, oblique, globose; inequilateral, posterior half produced; margins serrated; posterior margin rounded;

anterior margin almost straight; ventral and dorsal margins subparallel; umbo, hinge line, and wings missing. The decorations consist of about 30 low, narrow ribs radiating from the umbo and projecting over the margin, causing the serrated appearance described above. These ribs, which are more pronounced over the posterior than over the anterior region, are separated by broad, flat depressions which carry a varying number of radiating hair-like costæ. Lines of growth, although visible, are not conspicuous as a decorative feature.

This form resembles *L. wacoensis*, but may be distinguished from it by the greater number of large ribs and the presence of the hair-like costæ.

Locality.—Uncertain; probably Austin, Tex.

Collection.—United States National Museum.

LIMA WACOENSIS Roemer.

Pl. V, fig. 10.

Lima wacoensis Roemer, 1849, Texas etc., p. 399.
Lima wacoensis Roemer, 1852, Kreid. von Texas, pp. 63–64, Pl. VIII, figs. 7, a, b.
Lima wacoensis Conrad, 1857, Rept. U. S. Mex. Bound. Surv., Vol. I, Pt. II, p. 151, Pl. V, fig. 4, a, b.
Lima leonensis Conrad, 1857, Rept. U. S. Mex. Bound. Surv., Vol. I, Pt. II, p. 151, Pl. V, fig. 3, a, b, c.

Dimensions.—Length, 15 mm.; breadth, 14 mm.

Description.—Shell small, thin, oblique, globose; outline subovate; inequilateral; ventral and dorsal margins subparallel; anterior margin slightly curved; posterior margin elongate and rounded; umbos approximate; hinge line straight and oblique; wings small, undecorated, concave margins. Decorations consist of about 20 small ribs radiating from the umbo. These ribs are of unequal size, being larger over the domed region of the shell and smaller on either side.

This form is not very common.

Locality.—Shoal Creek, Austin, Tex.; Onion Creek, Buda, Tex.

This form has also been found in the Comanche Peak chalk, the Washita limestone, and the Del Rio clays.

Collection.—United States National Museum.

LIMA sp.

Pl. V. fig. 9.

Description.—This form is represented by one very imperfect cast of the interior of the right valve. Shell medium; inequilateral; dorsal margin straight, oblique, inflected at an angle of 90 degrees; shell most strongly arched in this region, sloping away in all directions; posterior, ventral, and anterior margins sinuous. About 20 delicate radiating ribs are indicated on this cast.

Locality.—Onion Creek, Buda, Tex.

Collection.—United States National Museum.

PERNIDÆ.

Genus GERVILLIOPSIS Whitfield.

GERVILLIOPSIS INVAGINATA (?) White.

Pl. V, fig. 12.

Dalliconcha invaginata White, 1887, New Generic Forms of Cret. Mol., etc.; Proc. Acad. Sci. Phil., p. 35, Pl. II, figs. 4, 5.

Description.—Shell narrow, depressed, inequilateral; greatly prolonged posteriorly; moderately thick; shaped and curved much like the blade of a scythe; central ridge running down its entire length midway between the margins; hinge line straight, exhibiting in the imperfect specimen about twelve crenulations, which rapidly increase in length until those directly under the beak are about 2 cm. long and of reduced strength; umbos low and terminal; decorations obscure.

The only specimens of this form are casts in such an imperfect state of preservation that they can only questionably be referred to the above-named species.

Locality.—Shoal Creek, Austin, Tex.

This form is also found in the Marietta and Fort Worth beds of northern Texas.

Collection.—United States National Museum.

Genus INOCERAMUS Sowerby.

INOCERAMUS sp.

Dimensions.—Length, 42 mm.; breadth, 57 mm.

Description.—Shell medium; margin not visible; general outline appears to be subovate; inequilateral, anterior portion slightly produced; somewhat ventricose; hinge line straight and situated obliquely to long axis; umbo prominent, produced, curved slightly forward; located at anterior end of hinge line, ears wanting. Decorations consist of plications and striations parallel with lines of growth.

This form appears to be very rare in the Buda limestone. The only specimen of this species is a cast of the interior right valve.

Locality.—Onion Creek, near International and Great Northern Railroad crossing, Travis County, Tex.

Collection.—United States National Museum.

PINNIDÆ.

Genus PINNA Linnæus.

PINNA sp.

Pls. VI, VII.

Description.—Shell elongate, subtriangular; increasing rapidly in breadth from the pointed anterior to the rounded posterior end; breadth not less than 6 cm., length not less than 16 cm. A preserved shell frag-

ment is situated near the posterior end of the right valve and bears on the surface equidistant, longitudinal furrows, while the cast of the inner surface of the left valve shows growth lines converging at the anterior end. These ridges are less conspicuous over the posterior portion of the valve.

In the Buda limestone, *Pinna* is a common form, but preserved almost entirely as casts. Of the eight specimens at hand, only two possess fragments of a shell, and these are too poorly preserved to be of use in specific determination.

Locality.—Shoal Creek, Austin, Tex.; Onion Creek, Buda, Tex.

Collections.—Johns Hopkins University; United States National Museum.

SPONDYLIDÆ.

Genus SPONDYLUS Linnæus.

SPONDYLUS sp.

Pl. VIII, figs. 1–3.

Dimensions.—Length, 40 mm.; breadth, 5 cm.

Description.—Shell medium, moderately thick, ventricose, inequilateral, produced anteriorly; umbos prominent, bent forward. Decorations consist of wavy, radiating ribs of medium strength, bearing at intervals bosses, which probably are the remnants of former spines.

To this description may be added that of certain smaller forms which are probably the young of this species. The shell is thin, small, globose; margin fluted; outline subovate; inequilateral; inequivalved; lower right valve produced in direction of anterior margin; large scar at point of attachment. The only decorations are fine, irregular, radiating lines, every sixth one of which is strengthened and bears the remnants of spines. The upper valve is also produced anteriorly, and bears decorations analogous to those on the right valve.

All of these forms are badly mutilated and it is therefore impossible to determine the species definitely.

Locality.—Shoal Creek, Austin, Tex.

Collections.—Johns Hopkins University; United States National Museum.

OSTREIDÆ.

Genus OSTREA Linnæus.

OSTREA sp.

Description.—This genus is represented by a fragment of a right valve, of which only the inner surface is visible. The oyster was large, and possessed near the ventral margin a conspicuous concave muscle impression. The margin is scalloped and the surface is smooth.

Locality.—Shoal Creek, Austin, Tex.

Collection.—United States National Museum.

Genus ALECTRYONIA Fischer.

ALECTRYONIA sp.

Description.—Shell medium, thick, corrugated; margin with the characteristic alectryonian fluting. The ribs, some of which show the bifid habit, are strong and sharp and radiate from the umbonal portion of the valve.

As only a portion of one valve is present, it is impossible to accurately determine this species.

Locality.—Uncertain, probably Shoal Creek, Austin, Tex.

Collection.—United States National Museum.

Genus GRYPHÆA Lamarck.

GRYPHÆA MUCRONATA Gabb.

Pl. IX.

Gryphæa pitcheri Roemer (not Morton), 1849, Texas, etc., pp. 394–395.
Gryphæa pitcheri Roemer, 1852, Kreid. von Texas, pp. 73–74, Pl. IX, fig. 1a, b, c.
Gryphæa pitcheri var. *navia* (in part) Hall, 1856, Rept. Expl. and Surv. R. R. from Miss. River to Pacific, Vol. III, Pt. IV, p. 100.
Gryphæa pitcheri var. *navia* Conrad (in part), 1857, Rept. U. S. Mex. Bound. Surv., Vol. I, Pt. II, p. 155.
Gryphæa pitcheri Owen (not Morton), 1860, Second Rept. Geol. Surv. Arkansas, pl. 7, fig. 6.
Gryphæa mucronata Gabb, 1869, Geol. Surv. Cal., Palæontology, Vol. II,, pp. 274–275.
Ostrea pitcheri Coquand (in part), 1869, Mon. du Genre Ostrea Terr. Crétacé, p. 40, Pl. IX, figs. 9–12.
Gryphæa navia (Conrad in part) White, 1884, Fourth Ann. Rept. U. S. Geol. Surv., p. 302, Pl. XLIX, figs. 3–6.
Gryphæa mucronata Hill and Vaughan, 1898, Bull. U. S. Geol. Surv. No. 151, pp. 63–65, Pls. XXIV-XXX.

Dimensions.—Length, 35 mm.; breadth, 4 cm.

Description.—Shell laterally subtrihedral; margin straight; inequivalved; inequilateral; lower valve very globose and thick in umbonal region, gradually thinning toward the ventral margin; beak prominent, submedial, slightly bent posteriorly; hinge line straight; ligamental fossa narrow, deep, curved; inside of shell smooth; anterior and posterior margins prominently elevated, the latter more than the former, imparting to the form a compressed aspect in the direction of its length. Surface decorations consist of undulating lines of growth more or less elevated at their margins, and a deep groove extending from beak to ventral edge, a little anterior to the posterior margin. Right valve subcircular, decorated externally with concentric lines of growth.

This is a common form at the base of the Buda limestone.

Locality.—Shoal Creek, Austin, Tex.; Onion Creek, Buda, Tex.

Hill and Vaughan, who have worked out this form with great care, state that—

Gryphæa mucronata occurs in greatest abundance in the upper portion of the Del Rio (*Exogyra arietina*) beds and in the base of the overlying Shoal Creek limestone from the Brazos southward to the Guadalupe. It is well shown in Shoal and Barton creeks, near Austin. North of the Colorado it occurs abundantly in the Grayson beds overlying the Main street limestone, as near Handley, a few miles east of Fort Worth, and northward toward Red River at Denison. It also occurs in the Trans-Pecos region and as far west as Sonora, according to Gabb.[a]

Collection.—United States National Museum.

Genus EXOGYRA Say.

EXOGYRA CLARKI sp. nov.

Pls. X, XI.

Dimensions.—Length, 72 mm.; breadth, 105 mm.

Description.—Shell large, somewhat thicker in umbonal region than at margins; outline elliptical to oval; inequivalved; inequilateral; lower valve very globose, elongated in the direction of its breadth, compressed in the direction of its length; umbo distinctly recurved, adherent, interior of shell smooth, as deeply concave as surface is convex; muscle impression subcentral. Concentric with and a little below the periphery is a broad, shallow groove which is produced by the sudden expansion of the margin. This groove receives the margin of the upper valve. The decorations consist of concentric lines of growth with undulating margins; as the crest of each undulation disappears beneath that of the one just preceding it, irregular ribs are produced which radiate from the umbo and distribute themselves over the surface. The upper valve presents a warped appearance, as if it had suffered compression in the direction of its length; interior surface smooth; muscle impression subcentral; hinge line straight; exterior surface shows concentric and elevated lines of growth, which constitute its only decoration.

This species differs from *Exogyra costata* Say in being less ponderous and broader in proportion to its length, and from *Exogyra sinuata* var. *americana* Marcou in being smaller, more convex, and in rising less abruptly from the margin in the umbonal region. It is easily distinguished from *Exogyra ponderosa* by the fact that it is far less ponderous and possesses growth lines which are more rugged and sinuous at their margins.

A few specimens of this species have been found in the Buda limestone.

Locality.—Shoal Creek, Austin, Tex.

Collection.—United States National Museum.

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[a] Bull. U. S. Geol. Survey No. 151, 1898, pp. 64-65.

MYTILIDÆ.

Genus MODIOLA Lamarck.

MODIOLA (?) sp.

Pl. VIII, figs. 4, 5.

Description.—Shell medium, slightly inflated; margin absent. Decorations consist of pronounced undulations approximately parallel with the lines of growth, so disposed that series of three or four concentrate themselves into one ridge, which is more prominent and less curved than any one of the separate individuals.

All the specimens are fragmentary casts of the external surface.

Locality.—Onion Creek, Buda, Tex.

Collection.—United States National Museum.

ARCIDÆ.

Genus CUCULLÆA Lamarck.

CUCULLÆA sp.

Dimensions.—Length, 85 mm.; breadth, 63 mm.

Description.—Shell large, inequilateral, posterior end greatly produced; ovate-triangular, ventricose; posterior margin subtruncate; ventral margin extensive, slightly curved; anterior margin short, sharply curved; umbos very strong and conspicuous; situated at anterior end of form, bending forward and inward; both muscle impressions strong; pallial line entire; cast shows faint indications of radial ribbing.

This forms appears to be rare. This collection possesses three internal casts. It bears a striking resemblance to *Cucullæa terminalis* Conrad: Rept. U. S. Mex. Bound. Surv., Vol. I, Pt. II, p. 148, Pl. IV, figs. 2, a, b.

Locality.—Shoal Creek, Austin, Tex.; Onion Creek, Buda, Tex.

Collection.—United States National Museum.

TRIGONIIDÆ.

Genus TRIGONIA Bruguiére.

TRIGONIA EMORYI Conrad.

Pl. VIII, fig. 6–8.

Trigonia emoryi Conrad, 1857, Rept. U. S. Mex. Bound. Surv., Vol. I, Pt. II, p. 148, pl. 3 fig. 2, a, b, c.

Dimensions.—Length, 6 cm.; breadth, 4 cm.

Description.—Shell medium, thick, very much swollen about the anterior region; posterior end greatly produced; anterior margin falling away rapidly with a bold curve; posterior and ventral margins

absent; umbos subterminal, approximate, slightly produced, recurved; muscle impression large, subcentral. The decorations consist of thirty or more strong, curved tubercled ribs becoming indefinite posteriorly. These ribs change direction in passing over the area, so as to form a chevron-like arrangement, and after changing direction again, pass over the escutcheon.

The specimens of this species are almost entirely confined to casts. The above description has been made from a wax impression, supplemented by the anterior fragment of a shell.

Locality.—Shoal Creek, Austin, Tex.; Onion Creek, Buda, Tex.; Bartons Creek, Austin, Tex.

This form has also been reported from the Lower Washita.

Collection.—United States National Museum.

CRASSATELLIDÆ.

Genus PTYCHOMYA Agassiz.

PTYCHOMYA RAGSDALEI (Cragin).

Pl. XII, Pl. XIII, fig. 1.

Pholadomya ragsdalei Cragin, 1895, Des. Invert. Fossils from Comanche series of Texas, Kansas, and Indian Territory: Fifth Ann. Pub., Colorado Coll. Studies, pp. 58–59.

Description.—Shell medium to large, subovate, depressed; inequilateral, somewhat produced posteriorly; hinge line broad and slightly curved; umbos low, directed forward; two cardinal teeth directed backward, one posterior lateral tooth; mantle entire. Decorations consist of three systems of ribs. The one most extensive and conspicuous occupies the broad middle portion of the shell; its ribs, about twenty-five or thirty in number, radiating from beak to margin and carrying numerous tubercles. The second system, situated in front of the first, consists of short curved ribs which take their origin, not from the umbo, but from the anterior margin of the first system, and produce with it the effect of chevrons, with the angle directed toward the umbo. The third system, being very narrow, is less conspicuous than either of the others, is located at the posterior margin, and consists of strong corrugations, originating in the same manner as the second system, but differing from it in being V-shaped, with the apex turned away from the beak.

This appears to be a rather common form, but is poorly preserved, the specimens being represented only as casts. The description was made from wax impressions.

Locality.—Shoal Creek, Austin, Tex.; Onion Creek, Buda, Tex.

This form is also found in the Main Street limestone at Denison.

Collections.—Johns Hopkins University; United States National Museum.

CARDIIDÆ.

Genus CARDIUM Linnæus.

Subgenus GRANOCARDIUM Gabb.

CARDIUM (GRANOCARDIUM) BUDAENSE sp. nov.

Pl. XIII, fig. 2-4.

Dimensions.—Length, 45 mm.; breadth, 55 mm.

Description.—Shell medium, thin, cordate, slightly inequilateral; anterior portion somewhat produced; very globose, especially toward the dorsal region, sloping from here abruptly posteriorly and more gently anteriorly and ventrally; hinge line slightly curved; umbos conspicuous, produced, incurved, located a little posteriorly to the center of the hinge line; anterior muscle impression strong, posterior impression larger, but less conspicuous. Surface decorations consist of numerous smooth, radiating ribs, separated by narrow grooves, from which arise alternate rows of coarse, long spines and minute granules.

This form differs from *Cardium* (*Granocardium*) *sabulosum* Gabb by possessing only one row of smaller tubercles between the large, while *sabulosum* possesses two and three rows of smaller tubercles between the large.

Locality.—Shoal Creek, Austin, Tex.; Bouldin Creek, Austin, Tex., contact with Eagle Ford shales; Onion Creek, Buda, Tex.

Collections.—Johns Hopkins University; United States National Museum.

Subgenus PROTOCARDIA Beyrich.

CARDIUM (PROTOCARDIA) TEXANUM Conrad.

Pl. XIII, figs. 5-7.

Cardium (*Protocardia*) *texanum* Conrad, 1857, Rept. U. S. Mex. Bound. Surv., Vol. I, Pt. II, p. 150, Pl. VI, fig. 6, a, b. c.

Dimensions.—Length, 86 mm.; breadth, 87 mm.

Description.—Shell small to very large, thick, very globose, slightly inequilateral; anterior portion somewhat produced; umbones prominent, produced, curved slightly downward and forward; posterior margin slightly truncated; anterior and ventral margins rounded; toward the posterior, shell slopes more rapidly than toward either the ventral or anterior margins. Decorations consist of about fifteen radiating ribs, roughly parallel with the posterior margin, and the remainder of the shell (about four-fifths) is covered with coarse concentric undulations parallel with the lines of growth and gradually increasing in strength toward the margin. In large specimens these undulations carry on their surfaces faint longitudinal striations.

This species is rather common in the Buda limestone.

Locality.—Shoal Creek, Austin, Tex.; Bartons Creek, Travis County, Tex.; Onion Creek, Buda, Tex. This form has also been found in the Comanche Peak chalk and the Washita limestone.

Collection.—United States National Museum.

CARDIUM (PROTOCARDIA) VAUGHANI sp. nov.

Pl. XIV, fig. 1-3.

Dimensions.—Length, 6 cm.; breadth, 65 mm.

Description.—Shell medium, moderately thick, cordate, slightly inequilateral; very globose; umbos prominent; anterior margin truncated; posterior and ventral margins slightly curving, uniting at an obtuse angle; muscle impressions deep. Decorations consist of thirty or more fine, radiating ribs confined to the posterior region and occupying about one-quarter of the shell surface, the remaining three-quarters being almost smooth.

This form differs from *Cardium hillanum* in being truncated anteriorly, in possessing a larger number of ribs, and in having the remainder of the shell smooth.

Locality.—Not indicated.

Collection.—Johns Hopkins University.

PACHYMYIDÆ.

Genus PACHYMYA Sowerby.

PACHYMYA AUSTINENSIS (?) Shumard.

Pachymya austinensis Shumard, 1859, Trans. Acad. Sci. St. Louis, Vol. I, pp. 604–605.

Pachymya austinensis White, 1879, Cont. to Invert. Palæ. No. 1, Cret. Fossils of West. States and Terr.: Eleventh Ann. Rept. U. S. Geol. and Geog. Surv. Terr., p. 298, pl. 8, figs. 1, a, b, and pl. 5, figs. 7, a, b.

Pachymya? austinensis Hill, 1889, Annot. Check List Cret. Invert. Fossils of Texas: Bull. Geol. Surv. Texas No. 4, p. 15.

Description.—The following is Shumard's original description: "Shell very large, length more than double the width and less than double the thickness; greatest width near the center, where the shell is very gibbous; subangulated diagonally from the posterior side of the beak to the anal extremity and sloping to the margins; posterior slope broad; sides constricted anteriorly by a broad, shallow depression, which commences some distance below the beaks and extends obliquely downward and backward to the base; superior and inferior margins subparallel; buccal end very short, narrowly rounded; anal end obliquely truncated, gaping, angulated at extremity; pallial margin concave in the middle, rounded before and very gently convex posteriorly; beaks nearly terminal, flattened, incurved, approximate; surface marked with irregular, concentric lines of growth.

"Length, 6.30 inches; width, 2.30; thickness, 3.64."

The specimens of this species are too fragmentary to permit of a positive specific determination. They, however, most strongly resemble *Pachymya austinensis* Shumard, and are therefore questionably referred to that species. As it is impossible to describe forms as poorly preserved as those at the disposal of the author, he has taken the liberty to quote the original description made by Shumard. The form described by Shumard came from the Fort Worth beds below the Buda limestone.

Locality.—Shoal Creek, Austin, Tex.

Collections.—Johns Hopkins University; United States National Museum.

CYPRINIDÆ.

Genus ISOCARDIA Lamarck.

ISOCARDIA MEDIALIS (Conrad).

Pl. XIV. figs. 4, 5; Pl. XV, figs. 1, 2.

Cardium mediale **Conrad, 1857, Rept. U. S. Mex. Bound. Surv., Vol. I, Pt. II, p. 149, Pl. IV, fig. 4, a, b.**

Isocardia (?) medialis **Hill, 1893, Pal. Cret. Form. Texas: Proc. Biol. Soc. Washington, Vol. VIII, pp. 31–32, Pl. II, figs. 4, 5, and Pl. III, fig. 6.**

Dimensions.—Length, 6 cm.; breadth, 6 cm.

Description.—Shell medium to very large, thick, very globose, subcircular; equivalved; inequilateral; anterior and posterior margins subtruncate; ventral margin profoundly and irregularly curved; hinge line curved; teeth, two strongly developed cardinals and one posterior lateral in each valve; ligament external; ligamental grooves deep; umbos prominent, produced, curved downward and forward; anterior muscle impression strong and deep; posterior weak and large, not often visible on poorly preserved specimens. The surface of the shell is decorated with fine concentric striations.

The majority of the specimens of this species are preserved as casts, from two of which impressions of the hinge area have been obtained, thus allaying the doubt expressed by Mr. Hill in his description. Certain of the casts vary slightly from the type in possessing less prominent beaks. One large specimen is less globose than one would expect, considering the size, and has probably suffered compression, as suggested by Mr. Hill in the description of the same species from the Glen Rose beds.

Locality.—Shoal Creek, Austin, Tex.; Bouldin Creek, Austin, Tex., contact with Eagle Ford shales; Onion Creek, Buda, Tex.; north of Waters 1½ miles, Austin and Northwestern Railroad; Williamsons Creek, near Travis County, Tex. This form has also been reported from the Comanche Peak chalk.

Collections.—Johns Hopkins University; United States National Museum.

PHOLADOMYIDÆ.

Genus PHOLADOMYA Sowerby.

PHOLADOMYA ROEMERI sp. nov.

Pl. XV, figs. 3–6.

Dimensions.—Length, 8 cm.; breadth, 7 cm.

Description.—Shell large, very globose, inflated anteriorly, becoming less so ventrally, depressed posteriorly; inequilateral; prolonged posteriorly; margin truncated anteriorly, oblique, describing a wide curve ventrally and dorsally; hinge line straight, slightly inclined backward; umbos inflated, conspicuous, produced, curved downward and forward, and located at anterior end of hinge line. Decorations, as indicated by the cast, consist of radiating ribs which extend from a line a little behind the umbonal ridge to the anterior margin. The remainder of the shell is smooth. The ribs consist of series of tubercles arranged in rows extending from umbo to margin, the space between two contiguous tubercles being about equal to the diameter of the tubercle itself.

This collection possesses two casts of this species, from which the description has been made. The form resembles *Cardium sancti-sabæ* Roemer, but differs from it in having the post-umbonal region more inflated, in being more truncated anteriorly, in the greater acuteness of the anterior-ventral marginal angle, and in the oblique curve of the ventral margin from this point backward.

Locality.—Shoal Creek, Austin, Tex.; Onion Creek, Buda, Tex.

Collection.—United States National Museum.

Genus HOMOMYA Agassiz.

HOMOMYA AUSTINENSIS sp. nov.

Pl. XVI, figs. 1–3.

Dimensions.—Length, 7 cm.; breadth, 5 cm.

Description.—Shell medium, somewhat globose; equivalved; inequilateral; produced posteriorly; anterior margin short, slightly curved; ventral margin gently curved; posterior margin not whole in specimen, probably gaping; dorsal margin straight, subparallel with ventral margin; umbos conspicuous, elevated, globose, curved downward, inward, and slightly forward, situated near anterior end of shell. The decorations consist of concentric growth lines of about equal strength. This form may be easily distinguished from *H. vulgaris* by the fact that it is much shorter and broader in proportion to its thickness. It is also much more compressed.

Locality.—Shoal Creek, Austin, Tex.

Collection.—Johns Hopkins University.

HOMOMYA VULGARIS sp. nov.

Pl. XVI, figs. 4–5; Pl. XVII.

Dimensions.—Length, 104 mm.; breadth, 48 mm.

Description.—Shell large, thin, elongate-ovate, globose; equivalved; inequilateral; greatly produced posteriorly; margin straight, anterior margin very short, slightly curved; ventral margin prolonged, extending backward with a long, gentle curve; posterior margin oblique downward, joining the ventral margin with a bold curve; dorsal margin straight, subparallel with ventral; umbos very globose, elevated, approximate, in contact, curving inward, downward, and slightly forward; situated at the anterior end of shell; anteriorly closed; posteriorly gaping; posterior portion produced and curved upward. The decorations consist of concentric lines of growth varying in intensity.

This form is longer and thicker than *H. austinensis* in proportion to its breadth.

This form, which is very common in the upper portion of the Buda limestone, is poorly preserved and has usually suffered considerable deformation.

Locality.—Shoal Creek, Austin, Tex.; Bouldin Creek, Austin, Tex., contact with Eagle Ford beds; Onion Creek, Buda, Tex.

Collections.—Johns Hopkins University; United States National Museum.

ANATINIDÆ.

Genus ANATINA Lamarck.

ANATINA AUSTINENSIS sp. nov.

Pl. XVIII, figs. 1, 2.

Dimensions.—Length, 75 mm.; breadth, 38 mm.

Description.—Shell medium, thin, elongate-ovate, somewhat globose; equivalved; inequilateral; anterior end greatly produced; umbos low, curved backward and downward, removed from the posterior end a distance equal to one-third the long diameter of the shell; ventral margins slightly curved and in contact, anterior and posterior margins about equally rounded, gaping; slight concavity in side of form immediately under umbo. The decorations consist of concentric undulations parallel with the lines of growth. This form may be distinguished from *A. texana* on account of its smaller size, lack of the pronounced depression in front of the umbos, as well as by the fact that the umbos are situated nearer the anterior end.

The collection possesses one specimen of this form, which is in a very poor state of preservation.

Locality.—Shoal Creek, Austin, Tex.

Collection.—United States National Museum.

Anatina texana sp. nov.

Pl. XVIII, fig. 3.

Dimensions.—Length, 10 cm.; breadth, 55 mm.

Description.—Shell large, ovate, slightly globose; equivalved; inequilateral; posterior region more contracted and more sharply rounded than anterior; umbos subcentral, produced, bent backward and downward; margins in contact ventrally, gaping at either end; cardinal margin concave at posterior side of beak, sloping away gently anteriorly; ventral margin slightly concave immediately under the umbos, subparallel with dorsal margin. Surface of shell slightly concave below the umbos; deep groove bending downward and backward, located just in front at the base of the umbos; surface shows faint concentric ridges parallel with lines of growth.

This form is larger than *A. austinensis.* It has a pronounced depression in front of the umbos, and the umbos are situated in about the middle of the dorsal side.

The only specimen of this form is an imperfect cast.

Locality.—Shoal Creek, Austin, Tex.

Collection.—United States National Museum.

GASTEROPODA.

PATELLIDÆ.

Genus PATELLA Linnæus.

Patella sp.

Pl. XIX, fig. 1.

Dimensions.—Height, 5 mm.; breath, 17 mm.

Description.—Shell small, compressed, conical; apex central and erect; aperture circular; diameter, 19 mm. Decorations consist of fine concentric lines crossed by radial ridges bearing much-weathered tubercles, concentrically arranged about the apex.

The collection possesses a single specimen of this form.

Locality.—Shoal Creek, Austin, Tex.

Collection.—Johns Hopkins University.

PLEUROTOMARIIDÆ.

Genus PLEUROTOMARIA de France.

Pleurotomaria stantoni sp. nov.

Pl. XX.

Dimensions.—Height, 65 mm.; breadth, 80 mm.

Description.—Shell large, elevated, having the form of a broad-based cone; umbilicated; suture distinct; whorls few, increasing rapidly and regularly in size; aperture not present; slitband groove-

like, narrow, traceable along the surface of each whorl, midway between the upper and lower margins; short, transverse ribs converge backward toward the groove; those below are thickly set, comparatively inconspicuous, and bear three tubercles each; those above are pronounced, less thickly placed, and bear likewise tubercles; spaces between these ribs broad, each one offsetting a rib of the underlying series; lower margin of each whorl bound with a revolving cord-like ridge bearing tubercles; under surface of body-whorl decorated with revolving ridges on which are tubercles so arranged as to give the effect of transverse ribs converging toward the center.

The internal cast of this form resembles that of *Pleurotomaria austinensis* Shumard, but the shell may be readily separated from it by the fact that in *P. stantoni* the decoration is very rugged and ornate, and the fine revolving lines present in *P. austinensis* are absent.

Locality.—Shoal Creek, Austin, Tex.; Bartons Creek, Travis County, Tex.; Onion Creek, Buda, Tex.

Collection.—United States National Museum.

TROCHIDÆ.

Genus TROCHUS Linnæus.

TROCHUS sp.

Pl. XIX, figs. 2, 3.

Dimensions.—Height, 15 mm.; breadth, 17 mm.

Description.—Shell small, pyramidal, moderately elevated; whorls four, slightly globose, increasing in size regularly and slowly; aperture and surface decorations wanting.

This species is represented in the collection by one small imperfect cast. The specific determination is therefore impossible.

Locality.—Shoal Creek, Austin, Tex.

Collection.—Johns Hopkins University.

TURRITELLIDÆ.

Genus TURRITELLA Lamarck.

TURRITELLA BUDAENSIS sp. nov.

Pl. XIX, figs. 4–6.

Dimensions.—Breadth, 10 mm.

Description.—Shell medium, elevated, spireform; whorls numerous; sutures conspicuous; imperforate; aperture not fully preserved; outer lip thin. Decorations consist of four revolving ridges bearing tubercles. In the higher regions of the spire these ridges are uniformly developed, but in the adult portion of the shell the two middle ribs are more emphasized than those on either side; the spaces between

are occupied with hair-like lines, of which one or two are slightly larger than the others.

This form differs from both *T. seriatim-granulata* Roemer and *T. planilateris* Conrad, in having four in place of five ribs, and from the latter in having the two middle ridges most conspicuous. The presence of four tubercled ribs, instead of six, provides a ready means of separation from *T. marnochi* White.

Locality.—Shoal Creek, Austin, Tex.; Bouldin Creek, Austin, Tex., contact with Eagle Ford shales; Bartons Creek, Travis County, Tex.; Onion Creek, Buda, Tex.

Collections.—Johns Hopkins University; United States National Museum.

CERITHIIDÆ.

Genus CERITHIUM Adanson.

CERITHIUM (?) TEXANUM sp. nov.

Pl. XIX, figs. 7, 8.

Dimensions.—Breadth, 10 mm.

Description.—Shell medium; spire elevated; whorls more than six; form narrow, imperforate; whorls small; aperture missing, canal at the anterior extremity. Decorations consist of numerous transverse, slightly curved ribs, each one of which is transformed into a tubercle at the upper part by means of a constriction; these tubercles often are a direct continuation of the ribs, but may at times alternate with them.

This form appears to be rare in the Buda limestone, for the collection contains but two specimens; one is an imperfect shell and the other is a portion of an external cast. The generic determination is therefore doubtful.

Locality.—Shoal Creek, Austin, Tex.; Bouldin Creek, Austin, Tex.

Collections.—Johns Hopkins University; United States National Museum.

STROMBIDÆ.

Genus HARPAGODES Gill.

HARPAGODES SHUMARDI (Hill).

Pl. XXI.

Pterocera shumardi Hill, 1889, Pal. Cret. Form. Texas,, Pl. II.

Dimensions.—Height, 115 mm.; breadth, 107 mm.

Description.—The following is Hill's original description: "Shell cylindrical, subfusiform, smooth, with outer lip expanded and flattened into a conspicuous wing; apex pointed; columella not seen, canal reflected as in dotted lines, but destroyed in chiseling specimen from massive stone in which it was embedded. Whorls eight, the

lower being two-thirds the length of the shell; sutures slight; wings three, ribbed or fingered in the specimen figured, but there are indications that there were formerly two more, making five in all; margin is strongly indented between the termini of the fingers; surface marked by strong parallel lines of growth."

This form is rather common in the Buda limestone.

Locality.—Shoal Creek, Austin, Tex.; Onion Creek, Buda, Tex.

Collections.—Johns Hopkins University; United States National Museum.

CYPRÆIDÆ.

Genus CYPRÆA Linnæus.

CYPRÆA sp.

Pl. XXII.

Dimensions.—Height, 7 cm.; breadth 65 mm.

Description.—Shell medium, low, spherical, imperforate; whorls four or five; globose; aperture long, narrow slit-like; outer lip broad, expanded, and extending from the aperture at almost a right angle; body-whorl very large, embracing about four-fifths of the preceding whorl; no decorations visible.

This appears to be a rare species in the Buda limestone, as only one specimen is present in the collection. The description has been made from an internal cast.

Locality.—Shoal Creek, Austin, Tex.

Collection.—Johns Hopkins University.

FUSIDÆ.

Genus FUSUS Lamarck.

FUSUS TEXANUS sp. nov.

Pl. XIX, fig. 9.

Dimensions.—Height, 67 mm.; breadth, 14 mm.

Description.—Shell moderately large, elevated, turreted; sutures deep; whorls few, convex, increasing in size regularly and slowly; imperforate; greater part of aperture missing; anterior siphonic-canal long (23 mm.), deep. Decorations consist of well-marked and equal revolving ridges crossed by a few, prominent transverse ribs, which in the body whorl are quite elevated at the suture line, but gradually die out as they pass over the whorl.

This species appears to be rare in the Buda limestone, for only half of an external cast is present in the collection. The description has been made from a wax impression.

Locality.—Shoal Creek, Austin, Tex.; Onion Creek, Buda, Tex.

Collection.—Johns Hopkins University.

Fusus sp.

Pl. XIX, figs. 10, 11.

Dimensions.—Breadth, 13 mm.

Description.—Shell small, elevated, conical; whorls convex, five or six in number; body-whorl large, globose, carrying a central ridge; imperforate; sutures deep; aperture not distinct, probably oval; possesses an anterior canal; internal cast shows distinct, revolving lines on the under side of the outer lip.

This form is represented in the collection by one cast.

Locality.—Shoal Creek, Austin, Tex.; Bouldin Creek, contact with Eagle Ford shales; Onion Creek, Buda, Tex.

Collection.—United States National Museum.

CEPHALOPODA.

NAUTILIDÆ.

Genus NAUTILUS Linnæus.

Nautilus texanus Shumard.

Pl. XXIII, figs. 1, 2; Pl. XXIV, figs. 1, 2.

Nautilus texanus Shumard, 1859, Trans. Acad. Sci. St. Louis, Vol. I, p. 590.
Nautilus texanus Hill, 1889, Annot. Check List Cret. Invert. Fossils of Texas: Bull. Geol. Surv. Texas No. 4, pp. 21, 43, 50.
Nautilus texanus Cragin, 1893, Cont. Invert. Pal. Texas Cret.: Fourth Ann. Rept. Geol. Surv. Texas, p. 236.
Not *Nautilus texanus* Gabb, 1864, Geol. Surv. California, Palæontology, Vol. I, p. 59, Pl. IX, fig. 3, a, b.

Description.—Size varies from small to rather large; laterally compressed; sides slightly convex; dorsal curve abrupt; umbilicus circular, shallow, distinct; volution subovate; anterior portion of aperture absent; posterior portion semielliptical, deeply excavated by preceding volution; longest diameter 10 cm.; width in broadest section 4 cm., broadest portion situated a little below the middle of aperture; septa moderately concave forward; sutures on leaving the umbilicus are directed forward for a short distance, then turn with a sharp curve and run backward for a slightly greater distance, turning again, this time with a broader curve; they run forward once more for a distance about equal to their previous backward course and pass over the dorsum with a wide curve; retrosiphonate; siphuncle continuing backward to preceding septum, situated in dorso-ventral plane, a little to ventral side of middle. Decorations consist of numerous simple, flat ridges which pass from the umbilicus forward, then turn with a wide curve backward for a short distance and pass over the dorsum with a sharp curve.

Locality.—Shoal Creek, Austin, Tex. This form has been reported from the limestone—Fort Worth.

Collection.—Johns Hopkins University.

NAUTILUS HILLI sp. nov.

Pl. XXIII, fig. 3; Pl. XXIV, figs. 3, 4.

Description.—Size varies from small to medium; subovate; compressed; dorsum boldly rounded; umbilicus, medium, circular, small; aperture not complete, increasing gradually in size; posterior portion semielliptical, deeply excavated by preceding volution; longest diameter measures about 105 mm.; greatest width a little below center; septa moderately concave forward; sutures on leaving the umbilicus are directed forward for a short distance, then turn with a sharp curve and run backward for a slightly greater distance, turning again, this time with a broader curve; they run forward once more for a distance about equal to their previous backward course and pass over the dorsum with a wide curve; siphuncle situated in dorso-ventral plane a little below the middle. The shell is without decorations and is smooth except for minute growth lines just distinguishable.

In this form the septa are more widely separated along the dorsum than in *Nautilus texanus*. External decorations are also absent.

Locality.—Shoal Creek, Austin, Tex.

Collection.—United States National Museum.

AMMONOIDEA.

Genus BARROISICERAS (?) Grossouvre.

BARROISICERAS TEXANUM sp. nov.

Pl. XXV, figs. 1, 2.

Dimensions.—Longest diameter, 9 cm.; diameter of umbilicus, 12 mm.; convexity, 2 cm.

Description.—Shell medium, subovate, compressed; umbilicus deep, medium, sides gently rounding to surface; body chamber incomplete, poorly preserved, increasing gradually in size, passing at least halfway around whorl; greatest thickness of shell about one-third distance from dorsal to ventral margin. As ribs pass from umbilicus over whorl they become somewhat curved and obscurely tubercled, and on the venter develop a low, oblong tubercle. Ribs 28 or more to the whorl. Sutures as a whole not extremely complex; as far as visible on specimen consist of a ventral superior and inferior lateral and two auxiliary lobes and an external lateral and three auxiliary saddles; of these the ventral lobe is the most complex in outline; the superior lateral less so; inferior lateral and auxiliaries progressively less complicated and rapidly decreasing in size until they disappear as mere notches; of the saddles the external is most sinous in outline, having a conspicuous notch in the center; lateral saddle slightly wavy; auxiliaries decreasing rapidly in size.

This species is represented by a single poorly preserved specimen.

Only fragments of the shell now remain adhering to the internal cast, and nowhere is the surface preserved. The suture lines appear to have suffered somewhat from solution.

Locality.—Little Bear Creek, Hays County, Tex.

Collection.—United States National Museum.

BARROISICERAS HYATTI sp. nov.

Pl. XXV, figs. 3, 4.

Dimensions.—Longest diameter, 4. cm.; diameter of umbilicus, 8 mm.; convexity, 15 mm.

Description.—Shell small, compressed; umbilicus deep, medium; sides sloping gently to surrounding surface; greatest thickness of shell about one-third distance from dorsal to ventral margin. As ribs pass from umbilicus over whorl they develop a slight double curve, carrying obscure tubercles, and on the venter develop a low, oblong tubercle. Suture not very complex; consists of ventral, superior, inferior lateral, and two auxiliary lobes and external, lateral, and three auxiliary saddles, ventral and superior lateral saddles of about equal complexity; inferior lateral and auxiliary lobes of progressively less strength and finally dwindle to mere notches; external and lateral saddles somewhat wavy in outline, but auxiliaries reduced to simple curves.

This species is represented by a fragment of an internal cast about an inch in length. A small portion of the shell still adheres to the cast, showing a smooth and undecorated surface.

Locality.—Shoal Creek, Austin, Tex.

Collection.—United States National Museum.

THE CORALS OF THE BUDA LIMESTONE.

By T. Wayland Vaughan

ANTHOZOA.

Parasmilia texana sp. nov.

Pl. XXVII, figs. 1–3.

Corallum short, subcornute; cross section elliptical, somewhat curved in the plane of the shorter transverse axis. Base not preserved intact, but evidently small.

Greater diameter of calice, 14 mm; lesser diameter of calice, 10 mm; height of corallum, 15.5 mm.

The costæ correspond to all cycles of septa, and are regularly alternately larger and smaller in size, the larger rather prominent. The edges are usually acute, both edges and sides granulate. No recognizable epitheca on the outside of the corallum. Septa in four complete cycles, reckoning six as the fundamental cycle. The margins are somewhat exsert. They are so-called entire; show no dentations, but some obscure crenations. The septal faces show striations, with granulations along their courses; the striæ are fine and alternate in position, i. e., the striæ on opposite sides of a septum do not stand opposite each other, but alternate with each other. The septal constitution, as interpreted from the striæ, is of ascending trabeculæ, with an area of divergence about corresponding in position with the wall. No pali could be discovered on any septum, the larger septa being directly continuous to the columella. The members of the first and second cycles and some of the third reach the columella. There is some dissepimental endotheca, and apparently occasional dissepiments exist between the costæ. The calicular fossa is moderately deep, not very narrow. The columella is very well developed, vesicular.

Locality.—Shoal Creek, Texas.

Type.—In the United States National Museum.

Remarks.—The only other species of *Parasmilia* from the Cretaceous of Texas is *P. austinensis* Roemer,[a] from the Edwards limestone,

[a] Ueber eine durch die Häufigkeit Hippuriten-artiger Chamiden ausgezeichnete Fauna der oberturonen Kreide von Texas. Mit 3 Tafeln. Palæontologische Abhandlungen, Vol IV, pt 4, Berlin, 1888, p. 284, Pl. XXI, Figs 1a, 1b.

near Austin. A most striking difference between the two species is, the costæ in Roemer's species are equal in size, while in *P. texana* they alternate most pronouncedly.

TROCHOSMILIA (?) sp. indet.

Pl. XXVII, figs. 4, 5.

This species is represented by a single broken specimen, from which one can not make out sufficient detail to determine the genus. The specimen is 19 mm. high; the broken base has a greater diameter of 8 mm.; the greater diameter of the calice is about 15.5 mm., and the lesser 10 mm. or slightly more. The corallum is very nearly straight; the calice is apparently inclined to the vertical axis, the shorter transverse axis not lying in a horizontal plane. Wall, solid; costæ well developed, corresponding to all septa, regularly alternating in size. The larger costæ are tall, narrow, and thin, with sharp edges. Over the costæ are many granulations. This is the extent of the detail that can be described.

Locality.—Shoal Creek, Texas.

Type.—United States National Museum.

CORAL sp.

Pl. XXVI, figs. 2, 3.

A fine, large, simple coral, whose size and form are shown by the figures. The whole of the interior of the corallum has decayed, therefore the genus can not be determined.

Locality.—Shoal Creek, Texas.

Specimen figured.—Johns Hopkins University.

ORBICELLA (?) TEXANA sp. nov.

Pl. XXVI, fig. 1; Pl. XXVII, fig. 6.

Corallum forming rather large masses, as much as 140 mm. high and more than that much across. The corallites are small, the usual diameter being between 1 and 2 mm.; they are crowded or not, the distance between adjacent corallites being in some cases as great as the diameter of the corallites. The costæ are prominent and join the corallites one to another. The usual number of septa is 20, 10 small and 10 large; they are much thicker at the wall than in the costal or inner portion. The lateral faces bear rather tall, erect spines. Exotheca present; endotheca rare. Columella poorly developed, composed of a few processes from the inner ends of the septa.

Locality.—Shoal Creek, Texas.

Type.—Johns Hopkins University.

Remarks.—The specimens referred to this species are embedded in a hard yellow limestone, the condition of preservation being such

that it is impossible to describe them in detail. There is a possibility that the species may be a *Stephanocœnia.* This species might be confused with *Astrocœnia guadalupæ* Roemer.[a] The latter species, according to Roemer's generic reference, would have a styliform columella, but his description of this part of the skeleton is not explicit. *A. guadalupæ* is an Edwards limestone fossil, as Roemer states, and the specimens have been changed into black flint. Flints are found only in the Edwards limestone in Texas.

LEPTOPHYLLIA sp. (No. 1.)

Pl. XXVII, figs. 9–11.

This specimen is fragmentary, being broken across the top. The transverse outline is not exactly but is approximately circular; the diameter of the upper broken end is about 20 mm.; the height of the specimen is about 14 mm. The outside of the corallum is not preserved in its original condition. No scar of detachment was seen. There appears to be no well-developed wall; the outer ends of the septa have a discontinuous coating over them that in part is probably epithecal in character. The septa are very numerous, thin, crowded, and extremely perforate. Nine septa were counted in the space of 5 mm. Synapticula are numerous, and apparently there are also some dissepiments. There is no columella. A considerable number of the larger septa reach the axial space.

Locality.—Shoal Creek, Texas.

Specimen.—In the United States National Museum.

LEPTOPHYLLIA sp. (No. 2.)

Pl. XXVII, figs. 7, 8.

The single specimen of this species is good, but not perfect. The chief difficulty in treating the species is that one specimen is not sufficient to give an adequate idea of all the essential specific characters.

The corallum is simple, irregular in shape, low, with an elliptical cross section. The base is not well preserved, but the corallum is apparently attached and the base is probably moderately large.

Greater transverse diameter, 20 mm.; greater diameter of calice, 16.5 mm.; lesser diameter of calice, 13.5 mm.; height of corallum, 11 mm.

Through an apparent deformity, the calice became constricted at a certain height above the base, so that the transverse diameters of the calice are not so great as the greatest diameters of the corallum. The figures show these features.

Neither true theca nor pseudotheca is present. There appears to be some epitheca. Synapticula are abundant between the peripheral

[a] Kreidebildungen von Texas und ihre organischen Einschlüsse, Bonn, 1852, p. 87, Pl. X, fig. 8, a, b.

ends of the septa. The septa are crowded, not very thick; as nearly as could be made out, in five cycles, six systems; the fifth cycle may not always be complete. Only a portion of the calice is well preserved. The septal faces are granulate; septal perforations fairly abundant, especially on the inner portions of the larger septa. Synapticula are rather abundant, and there may be, though I am not certain, an occasional dissepiment. There is no developed columella; the septa of the first, second, and third cycles, and some of the fourth, meet in the axial space.

Locality.—Shoal Creek, Texas.

Specimen described and figured.—United States National Museum.

This species differs from *Leptophyllia* sp. (No. 1) by being elliptical in cross section and having less perforate septa. The number of septa to 5 mm. is the same for both species. They may in reality belong to the same species, but such can not be proved from the material at my disposal.

PLATE II.

PLATE II.

P

PLATE III.

PLATE III.

PEC

PLATE II.

PLATE III.

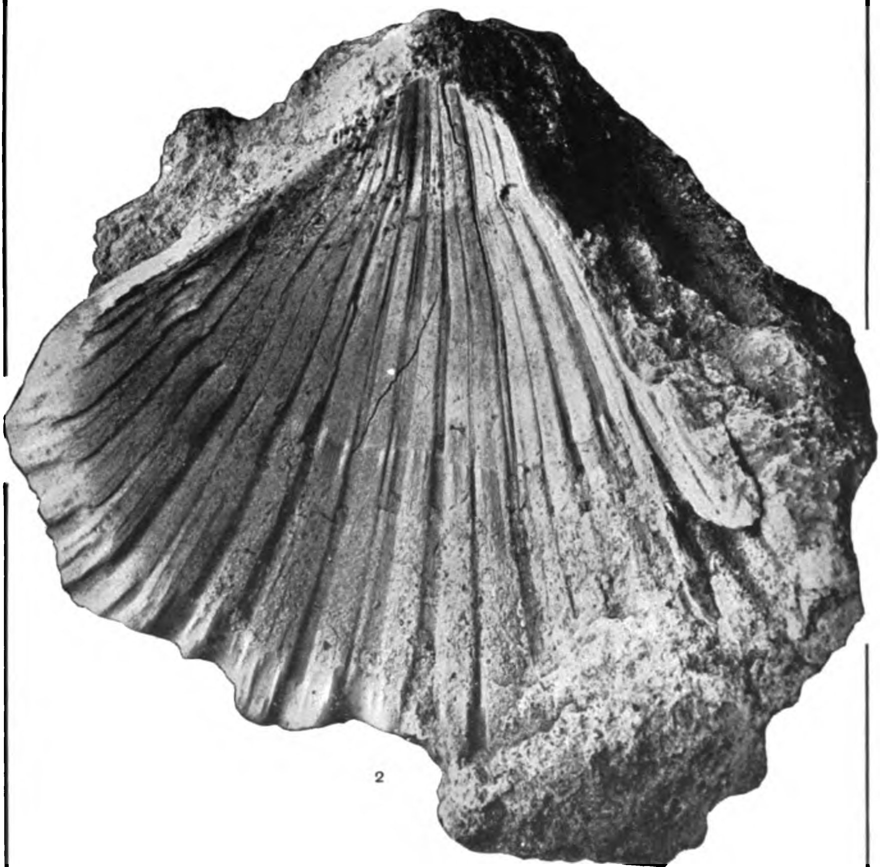
PLATE III.

PEC

PLATE IV.

PLATE IV.

1

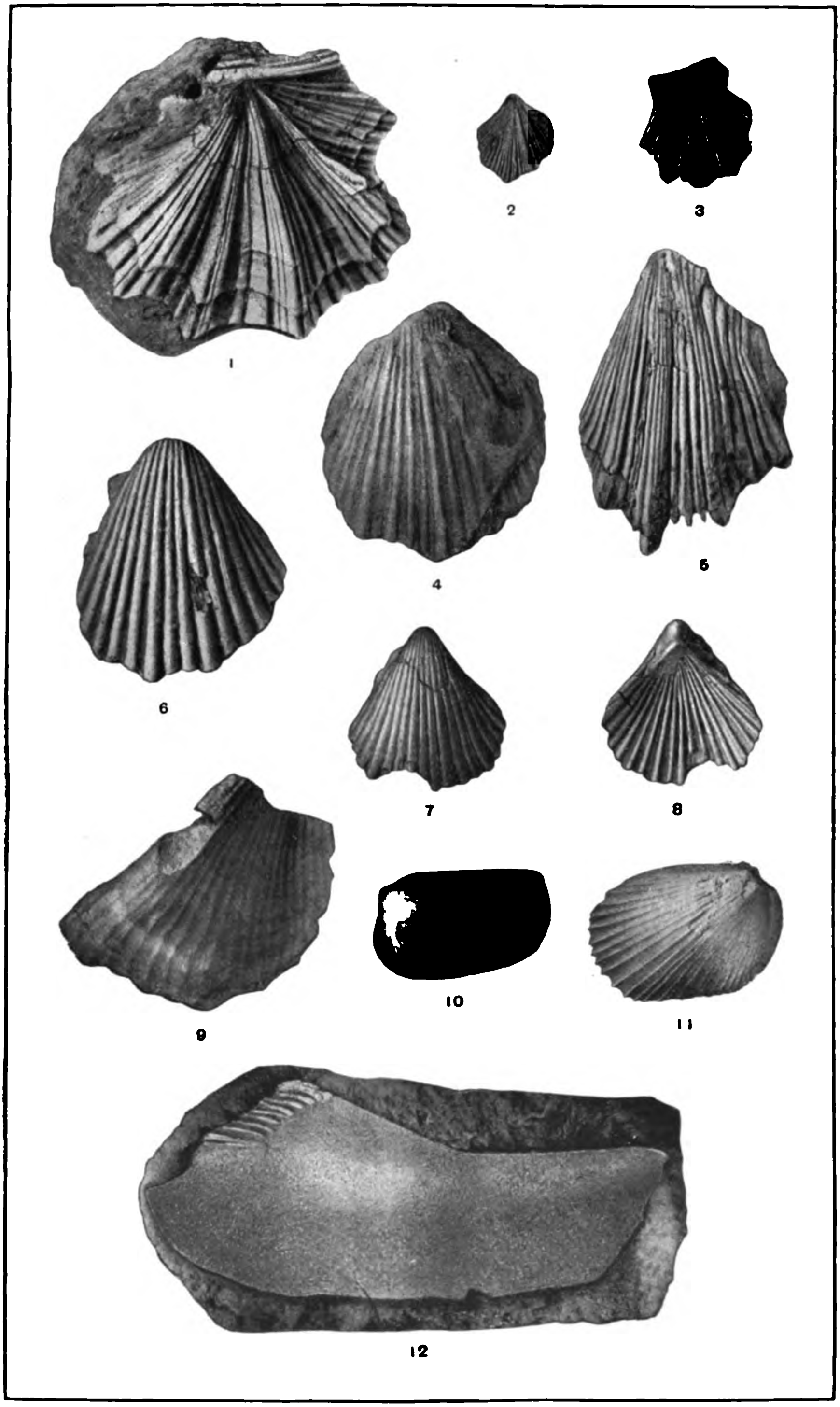


2

PECTEN ROEMERI (HILL).

PLATE V.

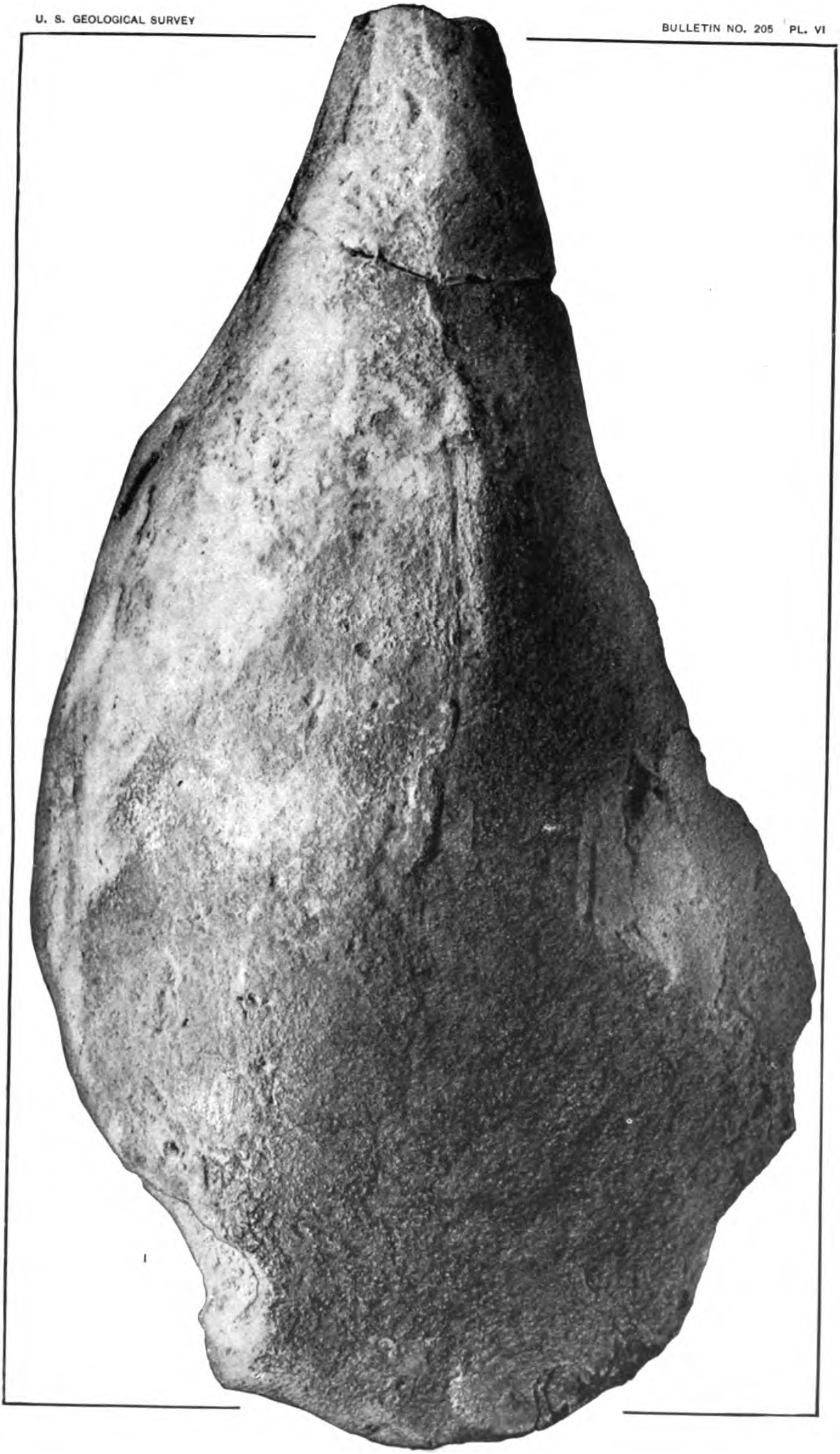
PLATE V.



PECTEN, LIMA, GERVILLIOPSIS.

PLATE VI.

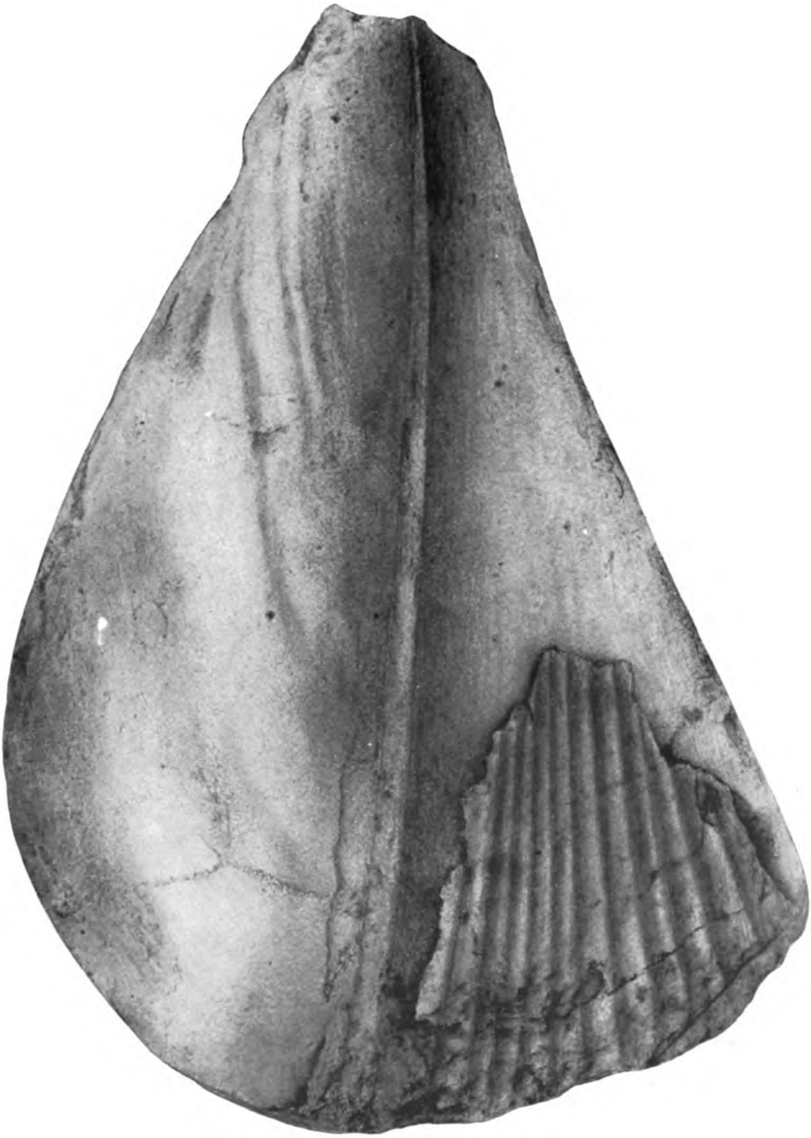
PLATE VI.



PINNA SP.

PLATE VII.

PLATE VII.

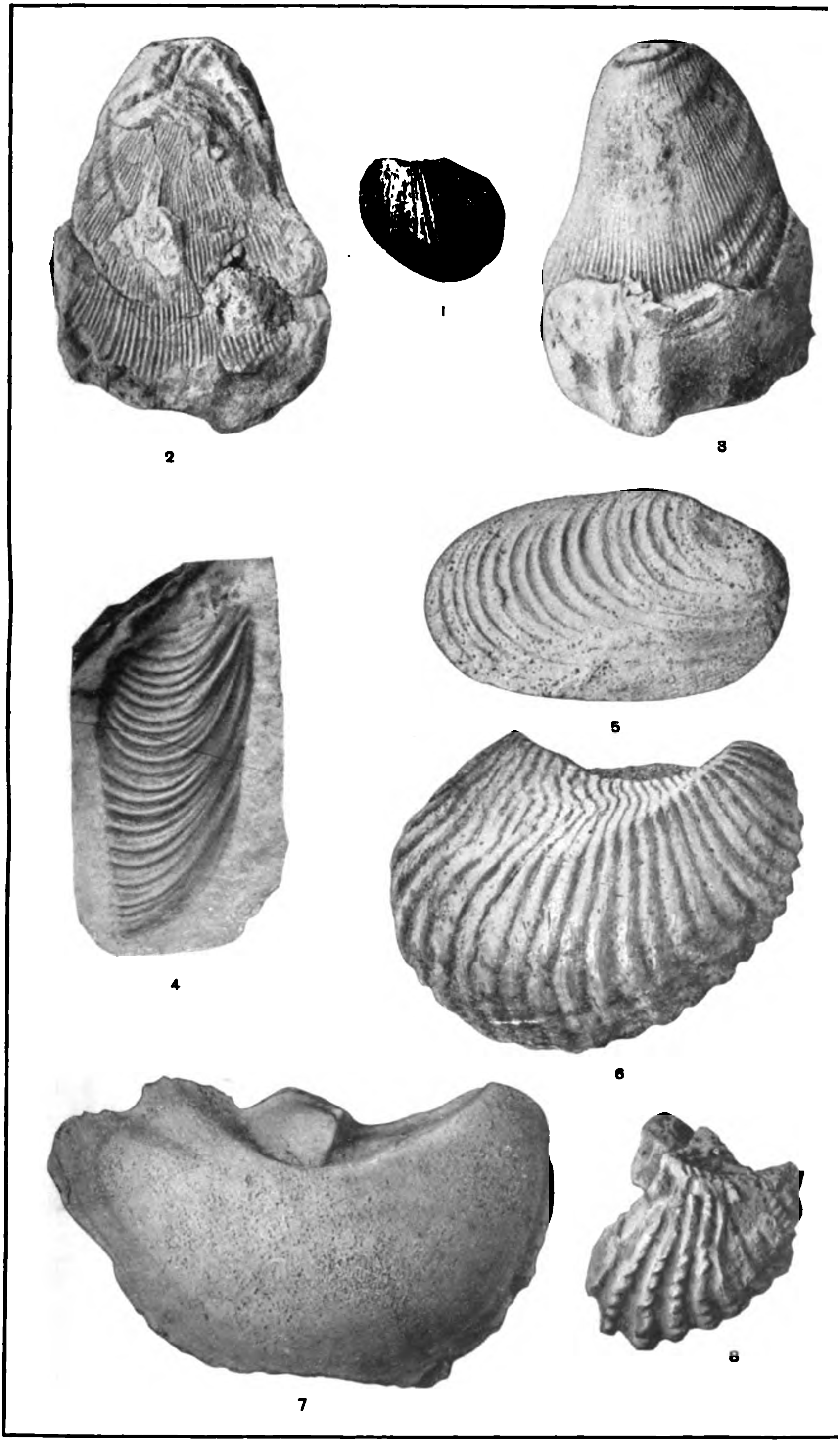


1

PINNA SP.

PLATE VIII.

PLATE VIII.



SPONDYLUS, MODIOLA, TRIGONIA.

PLATE IX.

PLATE IX.

1

2

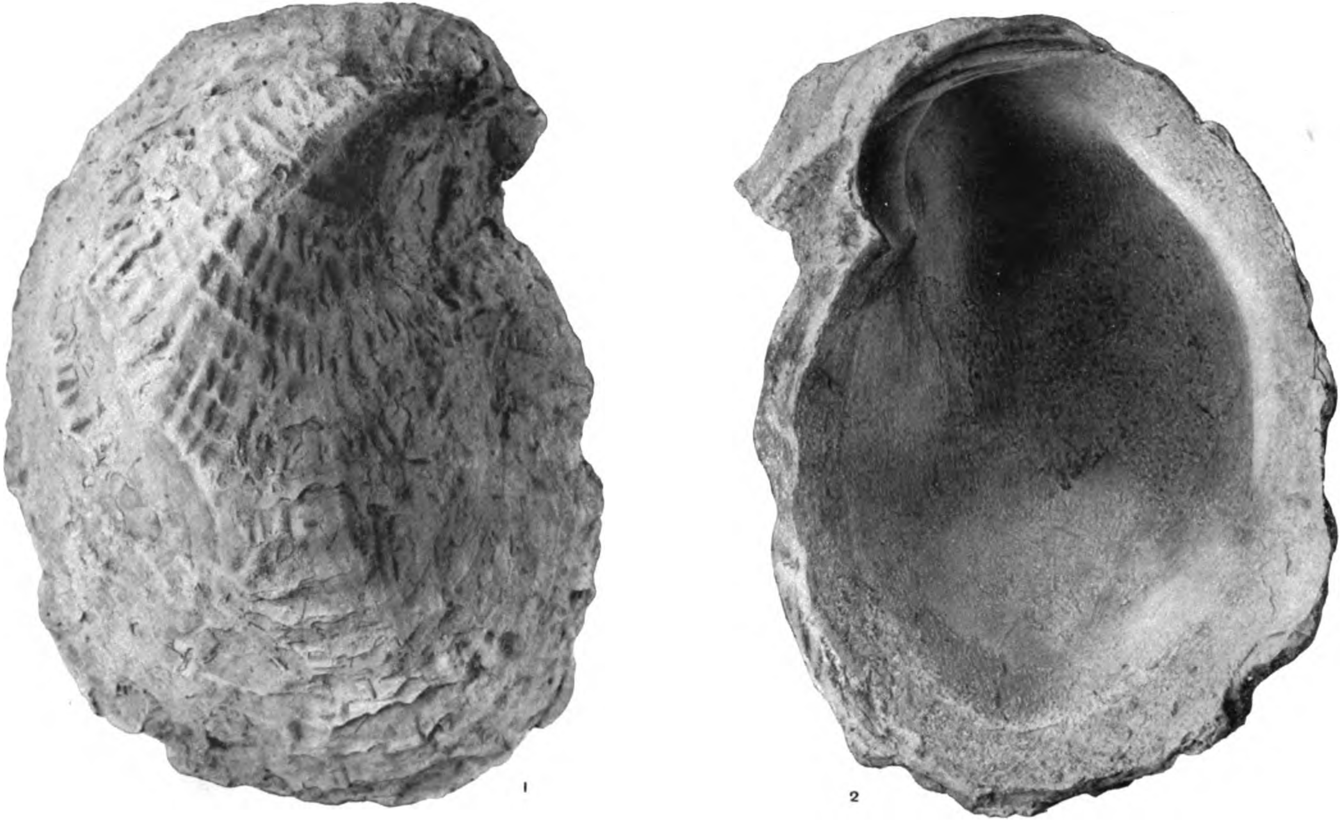
3

4

GRYPHÆA MUCRONATA GABB.

PLATE X.

PLATE X.



1

2

EXOGYRA CLARKI SP. NOV.

PLATE XI.

PLATE XI.

1

2

EXOGYRA CLARKI SP. NOV.

PLATE XII.

PLATE XII.

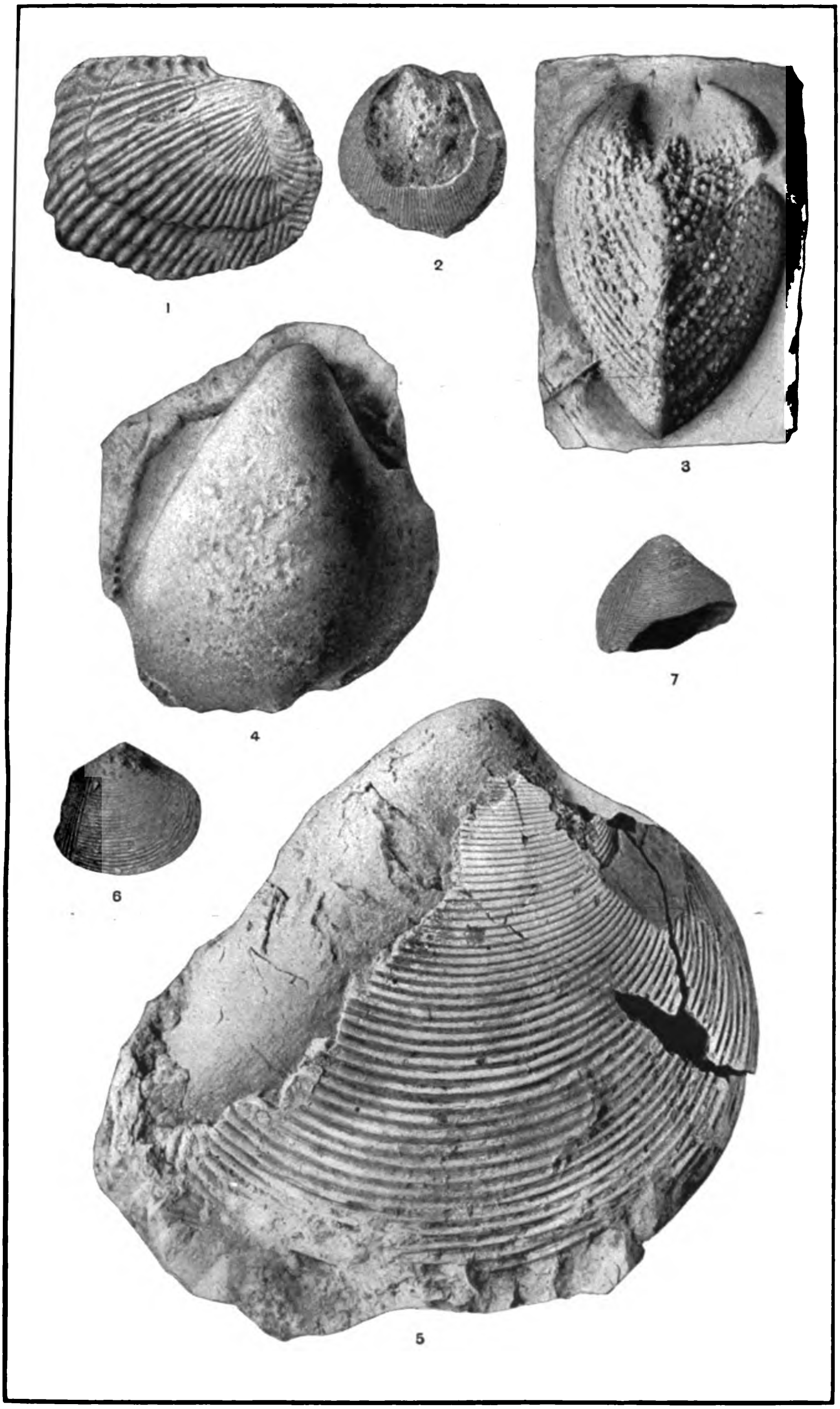
1

2

PTYCHOMYA RAGSDALEI (CRAGIN).

PLATE XIII.

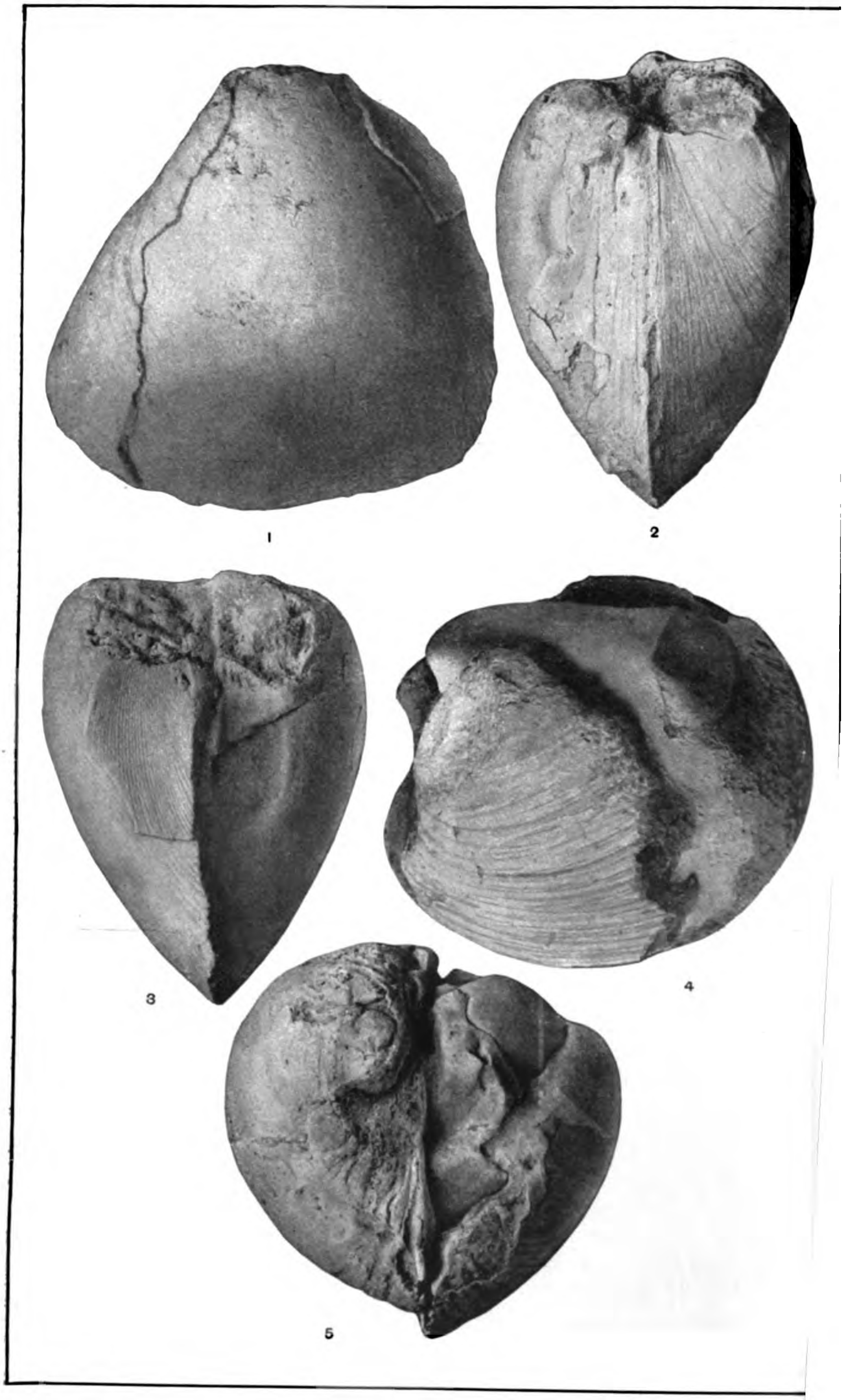
PLATE XIII.



PTYCHOMYA, CARDIUM.

PLATE XIV.

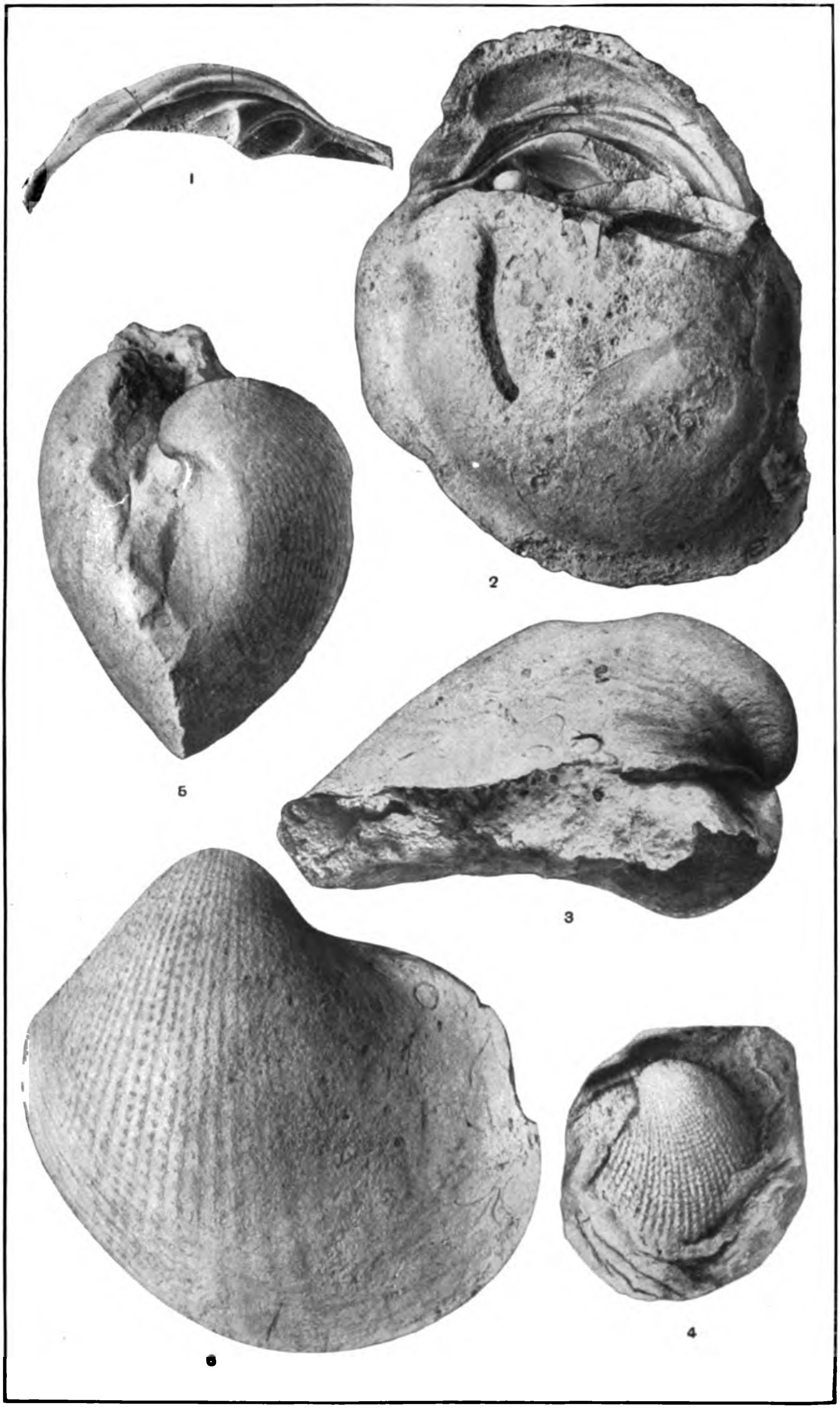
PLATE XIV.



CARDIUM, ISOCARDIA.

PLATE XV.

PLATE XV.



ISOCARDIA, PHOLADOMYA.

PLATE XVI.

PLATE XVI.

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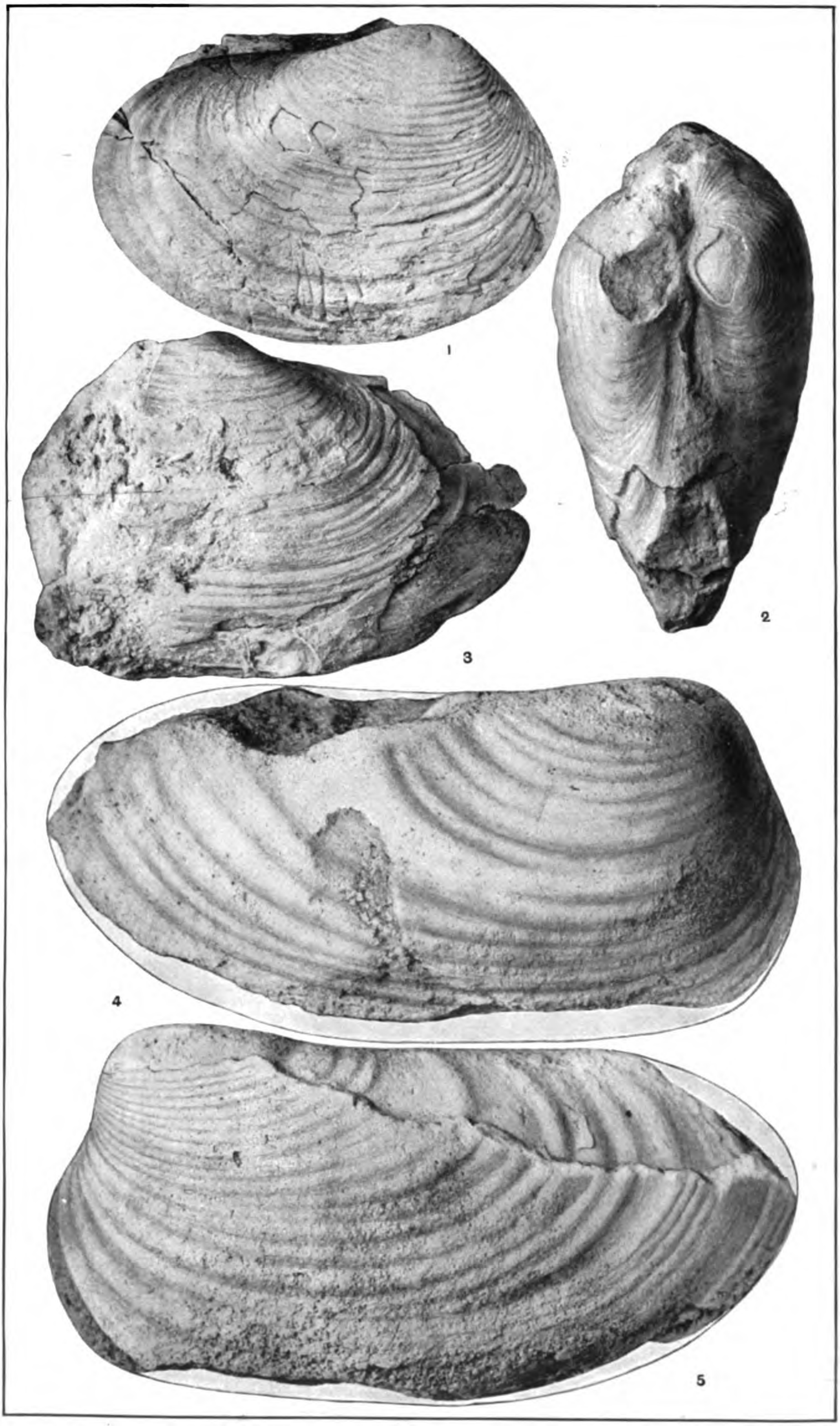


HOMOMYA.

PLATE XVII.

PLATE XVII.

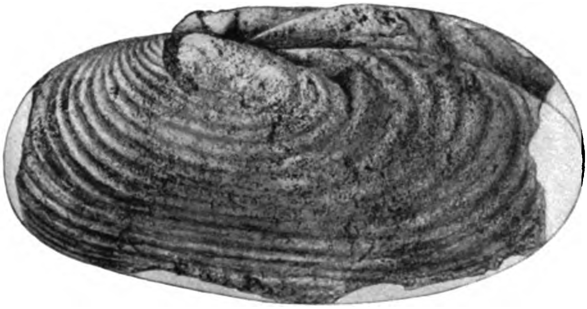
1

2

HOMOMYA VULGARIS SP. NOV.

PLATE XVIII.

PLATE XVIII.



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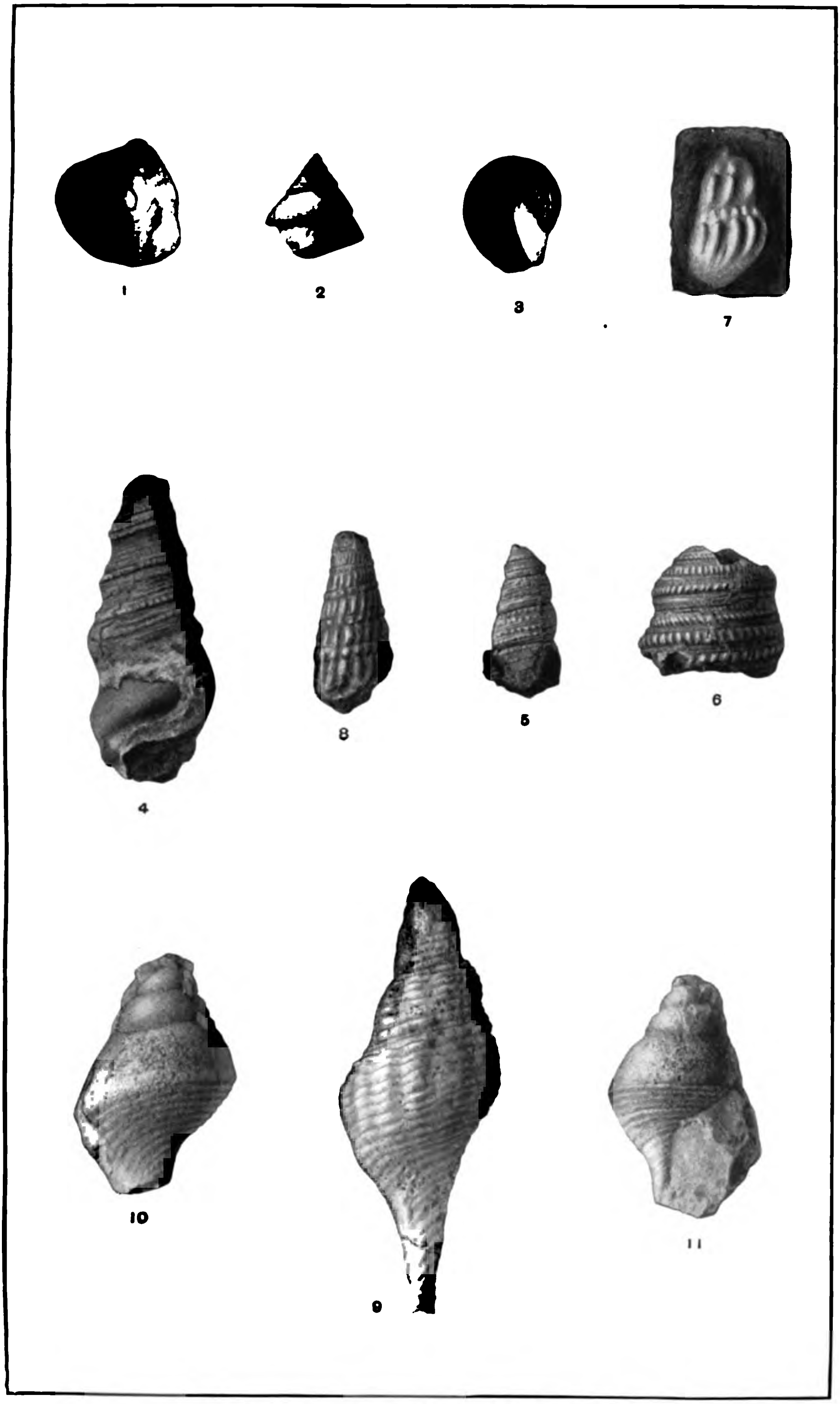
ANATINA.

PLATE XIX.

PLATE XIX.

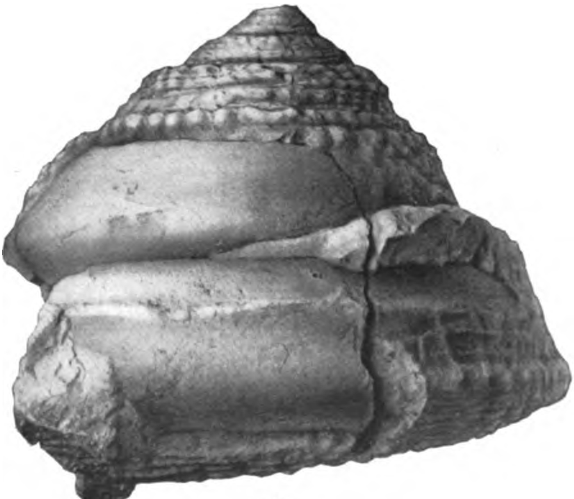


PATELLA, TROCHUS, TURRITELLA, CERITHIUM, FUSUS.

PLATE XX.

PLATE XX.

1

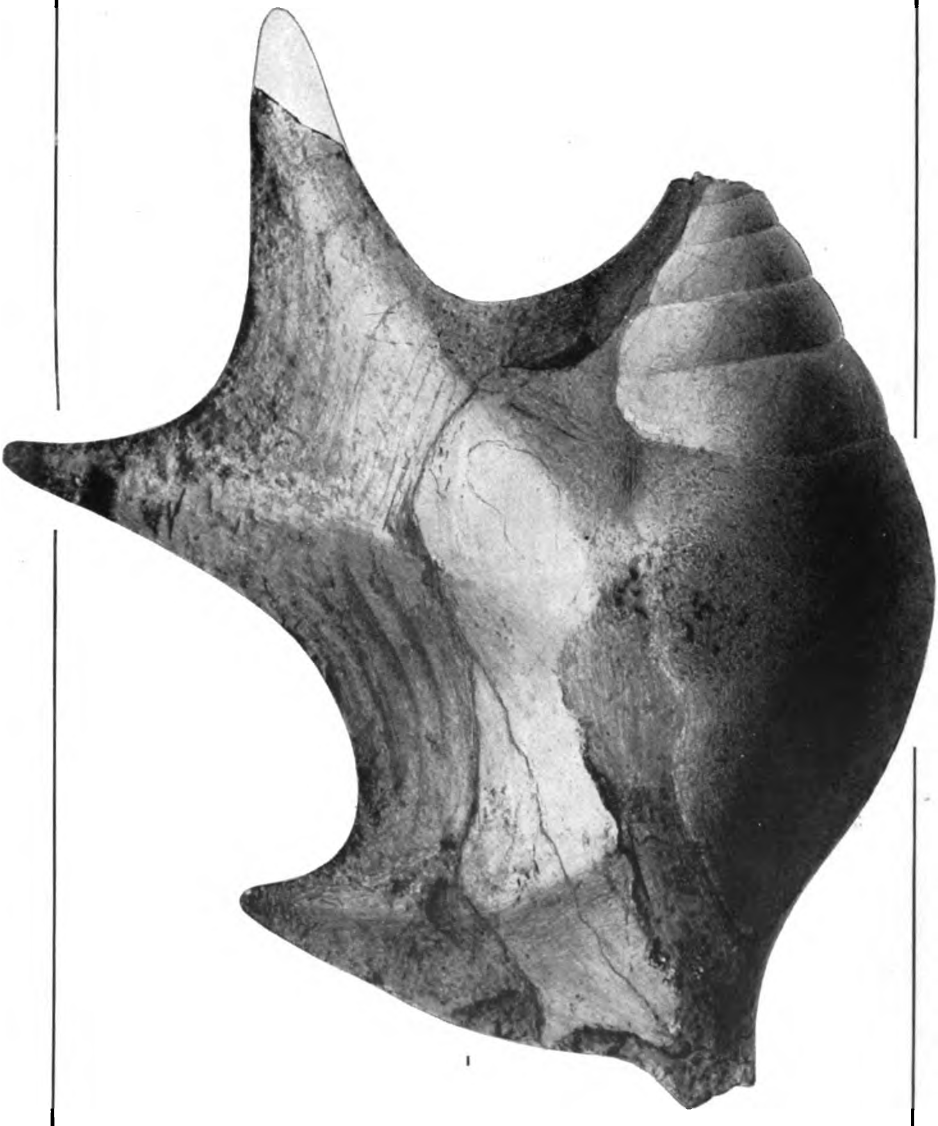


2

PLEUROTOMARIA STANTONI SP. NOV.

PLATE XXI.

PLATE XXI.



1

HARPAGODES SHUMARDI (HILL).

PLATE XXII.

PLATE XXII.

Page

Cypræa sp. 33

82

1

2

CYPRÆA SP.

PLATE XXIII.

PLATE XXIII.

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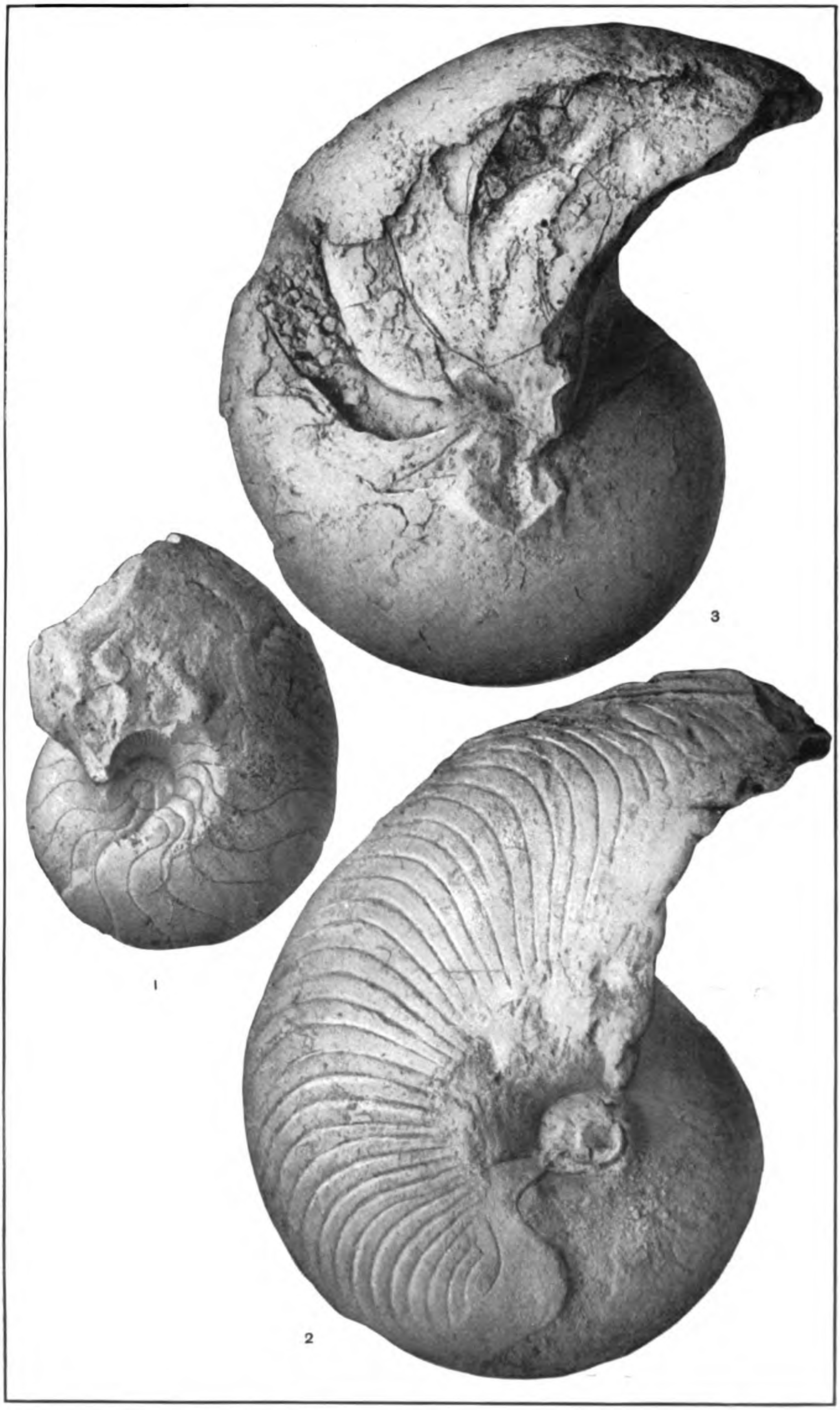

NAUTILUS.

PLATE XXIV.

PLATE XXIV.

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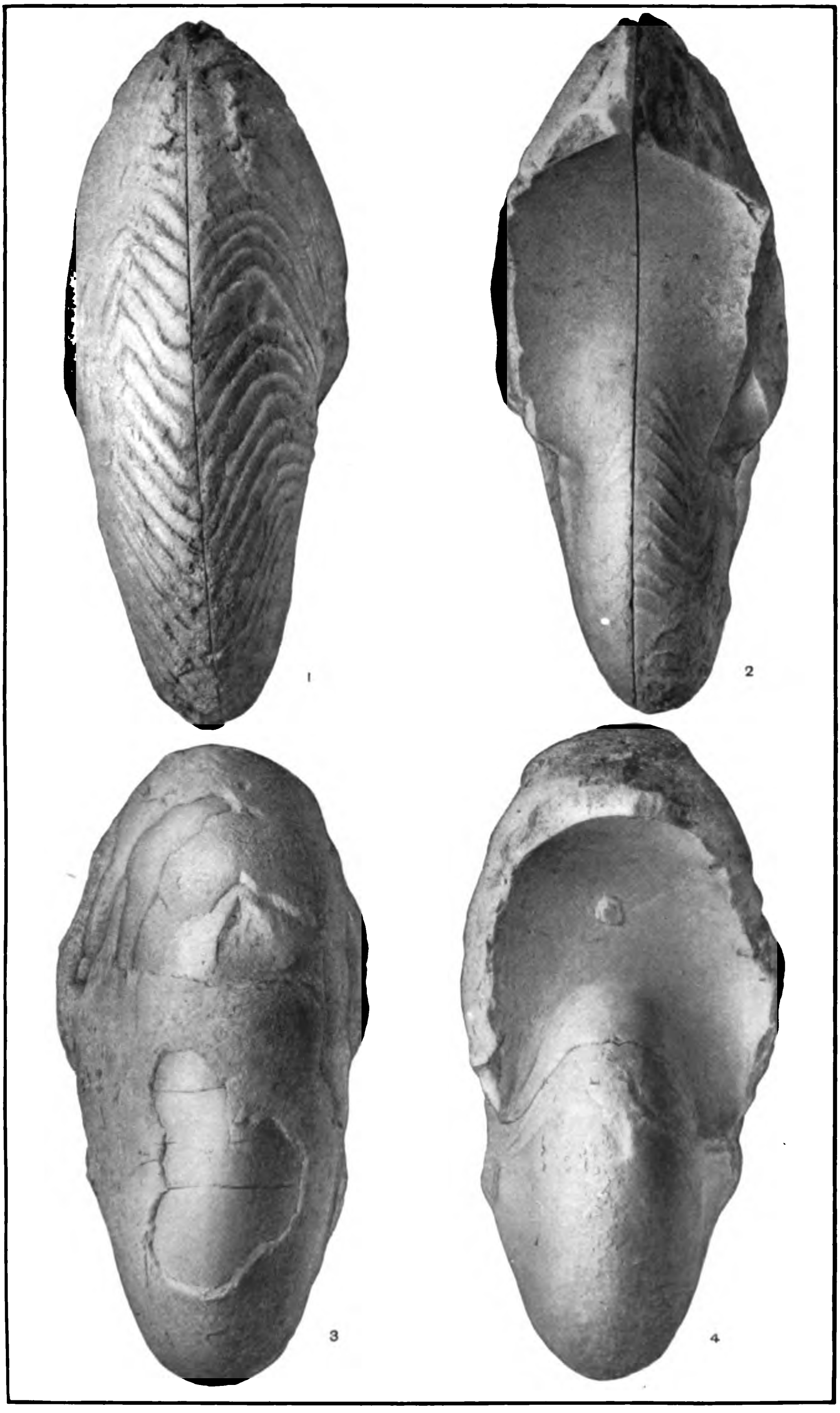


NAUTILUS.

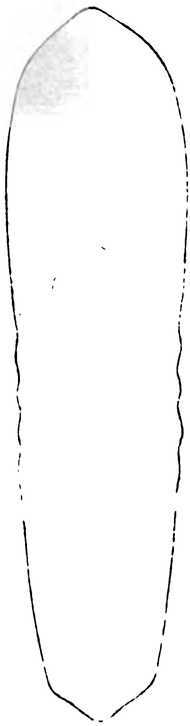
PLATE XXV.

PLATE XXV.

2

3

4



1

BARROISICERAS.

PLATE XXVI.

PLATE XXVI.

CORALS OF THE BUDA LIMESTONE.

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FIG. 1. Orbicella (?) texana Vaughan. General view of a specimen; height, as placed in figure, 126 mm	38
FIGS. 2, 3. Coral sp. Two views of the same specimen; height of specimen, 49.5 mm	38

1

2

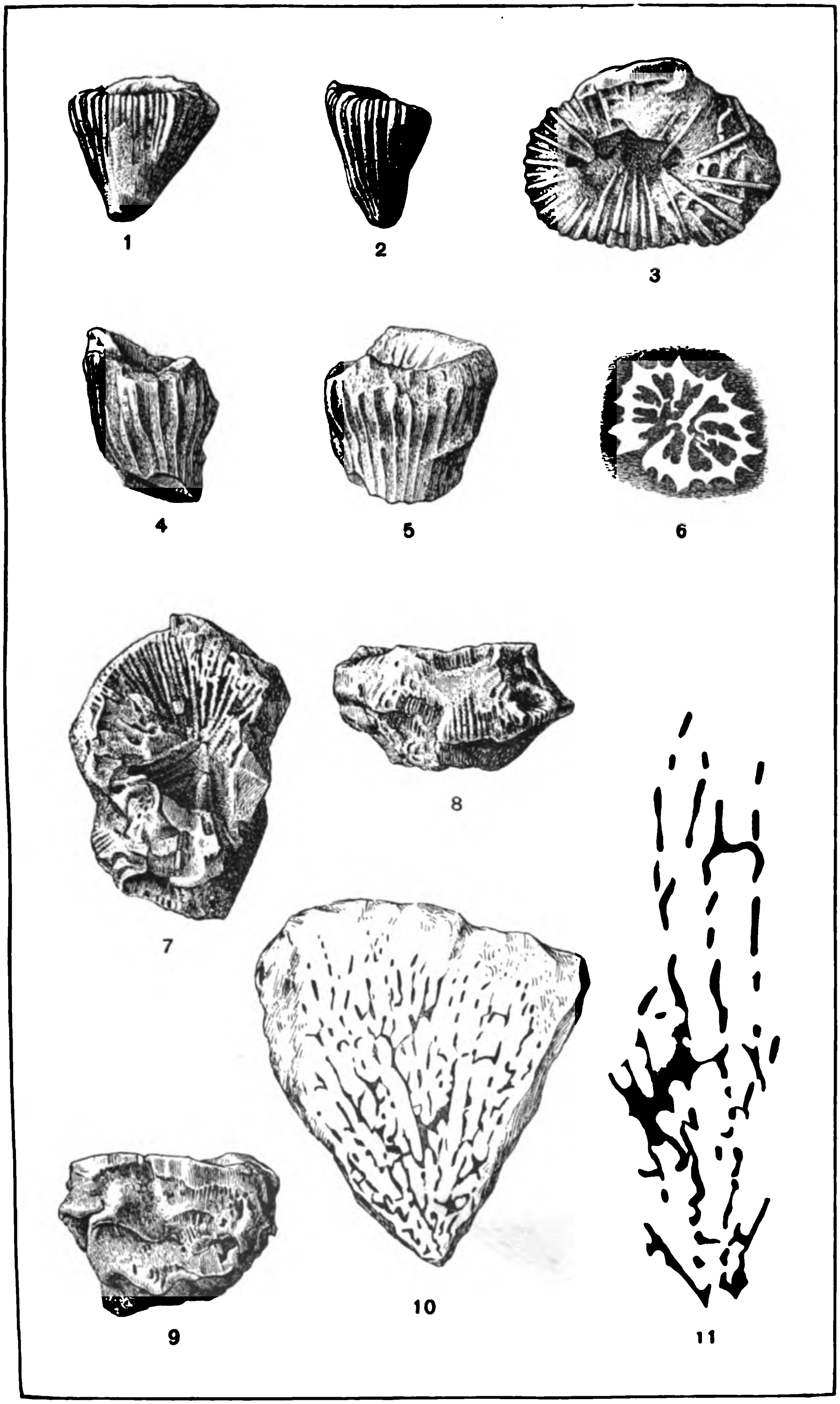
3

CORALS OF THE BUDA LIMESTONE.

PLATE XXVII.

PLATE XXVII.

CORALS OF THE BUDA LIMESTONE.



CORALS OF THE BUDA LIMESTONE.

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O

PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Bulletin No. 205.]

The serial publications of the United States Geological Survey consist of (1) Annual Reports, (2) Monographs, (3) Professional Papers, (4) Bulletins, (5) Mineral Resources, (6) Water-Supply and Irrigation Papers, (7) Topographic Atlas of United States—folios and separate sheets thereof, (8) Geologic Atlas of United States—folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists may be had on application.

The Bulletins, Professional Papers, and Water-Supply Papers treat of a variety of subjects, and the total number issued is large. They have therefore been classified into the following series: A, Economic geology; B, Descriptive geology; C, Systematic geology and paleontology; D, Petrography and mineralogy; E, Chemistry and physics; F, Geography; G, Miscellaneous; H, Forestry; I, Irrigation; J, Water storage; K, Pumping water; L, Quality of water; M, Methods of hydrographic investigations; N, Water power; O, Underground waters; P, Hydrographic progress reports. This bulletin is the fifty-ninth number in Series C, the complete list of which follows (all are bulletins thus far):

SERIES C, SYSTEMATIC GEOLOGY AND PALEONTOLOGY.

3. Fossil faunas of Upper Devonian, along the meridian 76° 30′, from Tompkins County, New York, to Bradford County, Pennsylvania, by H. S. Williams. 1884. 36 pp.
4. Mesozoic fossils, by C. A. White. 1884. 36 pp., 9 pls.
10. Cambrian faunas of North America. Preliminary studies, by C. D. Walcott. 1884. 74 pp., 10 pls.
11. Quaternary and recent mollusca of the Great Basin, with descriptions of new forms, by R. Ellsworth Call. Introduced by a sketch of the Quaternary lakes of the Great Basin, by G. K. Gilbert. 1884. 66 pp., 6 pls.
15. Mesozoic and Cenozoic paleontology of California, by C. A. White. 1885. 33 pp.
16. Higher Devonian faunas of Ontario County, New York, by J. M. Clarke. 1885. 86 pp., 3 pls.
18. Marine Eocene, fresh-water Miocene, and other fossil mollusca of western North America, by C. A. White. 1885. 26 pp., 3 pls.
19. Notes on the stratigraphy of California, by G. F. Becker. 1885. 28 pp. (Exhausted.)
22. New Cretaceous fossils from California, by C. A. White. 1885. 25 pp., 5 pls.
24. List of marine mollusca, comprising the Quaternary fossils and Recent forms from American localities between Cape Hatteras and Cape Roque, including the ermudas, by W. H. Dall. 1885. 336 pp.
29. Fresh-water invertebrates of the North American Jurassic, by C. A. White. 41 pp., 4 pls.
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Bulletin No. 206 Series C, Systematic Geology and Paleontology, 60

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

A STUDY

OF THE

FAUNA OF THE HAMILTON FORMATION OF THE CAYUGA LAKE SECTION IN CENTRAL NEW YORK.

BY

HERDMAN FITZGERALD CLELAND

WASHINGTON
GOVERNMENT PRINTING OFFICE
1903

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ILLUSTRATIONS.

LETTER OF TRANSMITTAL.

YALE UNIVERSITY,
New Haven, Conn., June 23, 1902.

SIR: I have the honor to transmit herewith, for publication as a bulletin of the United States Geological Survey, the manuscript of a paper entitled A Study of the Fauna of the Hamilton Formation of the Cayuga Lake Section in Central New York, prepared at my suggestion by Herdman Fitzgerald Cleland.

Respectfully, yours,

HENRY SHALER WILLIAMS,
Geologist and Paleontologist.

Hon. CHARLES D. WALCOTT,
Director of United States Geological Survey.

INTRODUCTION.

By Henry Shaler Williams.

The following paper is a contribution to the knowledge of the fossil faunas of the Devonian of the United States. It was begun by Mr. Cleland as a piece of research work in the course of study for the doctorate degree at Yale University, and was used as a thesis in taking the degree of doctor of philosophy in June, 1900. During the summer of 1901 some additional work was put on it, based upon more extended field work.

The value of the investigation consists chiefly in the statistics it furnishes as to the approximate composition of each of the successive faunules making up the total fauna occupying the Hamilton formation of central New York. In it account is given of the species obtained in a careful and full examination of every foot of the section from the top of the Onondaga (Corniferous) limestone to the base of the Tully limestone, both of which are well marked in the Cayuga Lake section, thus constituting definite limits for the Hamilton formation of this particular region.

All the fossiliferous zones (seventy-six in number) were examined, and upon analysis of the faunules of each zone those which were so closely alike as to signify practically the same set of species, associated in the same biological equilibrium of relative abundance, were grouped together, constituting in all twenty-five separate faunules. These may properly be described as the faunules of the twenty-five successive hemeræ into which the Hamilton epoch of this section may be distinguished by its fossils. These faunules are associated with more or less definite changes in the character of the sediments in which they were buried. The separate divisions of the formation thus recognized by slight differences in faunal composition as well as in lithologic constitution may be called zones. The Hamilton formation, its fauna, and the particular section here studied are well known to paleontologists, so that the species can be easily recognized and listed. In making the collections special attention was given to the discovery of the relative abundance of the species found associated together in each rock stratum. Direction was given to collect the fossils as near as possible in the proportion of numbers presented by the natural occurrence in the rocks. Instead of attempting to dis-

cover rare species, the purpose was to let the preserved collection represent as perfectly as possible the natural proportion of association. The working up of the collection was made to express this natural proportion expressed by the species.

The identification of species is probably always affected more or less by personal judgment. In order to make the statistics of the greatest relative value, therefore, no attempt was made to criticise these personal elements in the author; and while it is probable that another worker dealing with the same specimens would not reach absolutely identical listing of species, it is probable that the errors, if any, from inaccuracy of specific identification are so small relatively as to not disturb the statistical value of the facts recorded. Further and more exhaustive search, also, may be expected to considerably modify the statistics here given; but even this fact does not detract from the value of those here recorded. The more refined the analyses become the more perfect will be our knowledge of faunal compositions. The present investigation is a step in the direction of attaining the fullest possible perfection in recording faunal statistics, and in making these faunal analyses as perfect as they can be made, toward which end the contributions of many workers will be needed. With such statistics in hand we may hope to understand better the laws of evolution as affected by and related to the varying conditions of environment and time.

It will be noticed that the thickness of the Hamilton, as measured by Prosser in the Ithaca well, is 1,224 feet—that is, between the top of the Onondaga (Corniferous) limestone and the base of the Tully limestone. The exact thickness was not determined by the author. The reason for this is that the great thickness and similarity in the character of the rock of Zones B and C made the accurate measurement of these zones impossible. This is shown in the section (fig. 2) by broken lines. Nevertheless it is believed that the discrepancy does not affect the accuracy of the succession of the fossiliferous zones recorded in this paper. Attention is here called to the fact in order to show how difficult it is to make exact correlation for short distances when the sediments are of similar composition and structure and the general fauna is the same. For the purpose of ascertaining the exact thickness of each zone, a continuous section is necessary, but a long series of shorter sections, where the dip is slight, offers the advantage of a greater number of exposures of the rocks for the collection of the fossils. It is hoped that the present sample of what can be done in the way of an historical study of a fossil fauna may inspire other workers to make similar studies of the rocks in their own localities for comparison and demonstration of the geographical as well as the geological modifications of fossil faunas.

PREFACE.

The material for this study was collected during three months of the summer of 1899 and during May, 1901, from the Hamilton formation exposed along the east side of Lake Cayuga and the west side of Seneca Lake. Commencing at the Onondaga (Corniferous) limestone, an attempt was made to collect the complete faunule from each zone throughout the entire Hamilton formation up to the Tully limestone.

In the identification of the fossils the principle has been followed that unless absolutely necessary no new species or varieties should be described, but that all doubtful specimens should be referred to species already figured.

The writer is indebted to Prof. H. S. Williams for many helpful suggestions concerning methods of work.

A STUDY OF THE FAUNA OF THE HAMILTON FORMATION OF THE CAYUGA LAKE SECTION IN CENTRAL NEW YORK.

By HERDMAN FITZGERALD CLELAND.

CHAPTER I.

GENERAL DESCRIPTION AND GENERAL GEOLOGY OF CAYUGA LAKE REGION.

GENERAL DESCRIPTION.

The region studied is about 70 miles west of the center of New York State, and extends across about one-third of the State from north to south, the center of the region being nearly in the center of the north-south line. Cayuga Lake, along the east side of which the material for this study was collected, is one of the so-called "finger lakes" of the State, and, with its outlet, forms the boundary between Seneca and Cayuga counties.

In the western two-thirds of the State the strata strike in an east-west direction and dip to the south. Because of this southerly dip it is possible for one to see a large part of the Paleozoic section in a comparatively short distance in passing from north to south. The Cayuga Lake region itself embraces all of the formations between and including the Salina and the Ithaca.

This region is overlain by glacial drift, which hides the rock, except where worn away by erosion. Almost every stream that enters the lake has cut a deep gorge through the drift and into the shale, making excellent exposures. The gorges thus formed often have banks of shale 100 feet or more in height. In all of these creeks there are from one to four falls, the highest of which are caused by four strata of limestone and the hard sandstones or flags of the Portage. A description of Shurger Glen, about 5 miles from the south end of the lake, will, in a general way, answer for all the streams flowing into the lake, the only difference being that the streams farther down the lake do not flow over the Tully limestone, Portage sandstone, etc.,

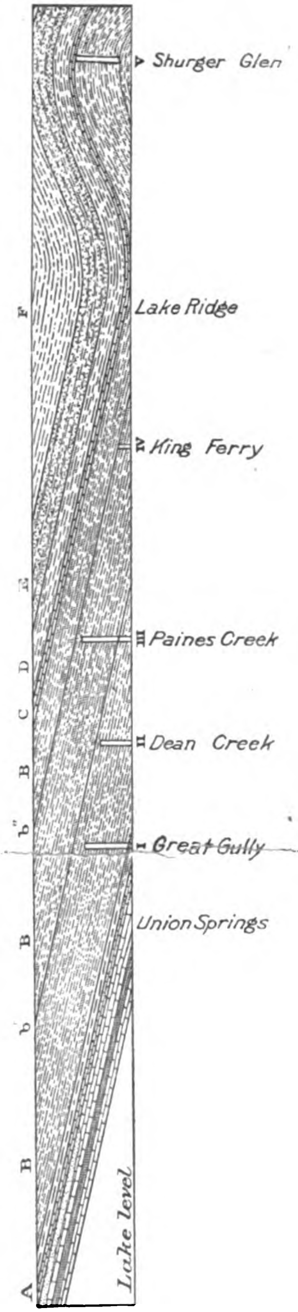


Fig. 1.—Cayuga Lake section. A, Marcellus shale; B, Hamilton formation; b', limestone of zone D; b'', Encrinal beds; C, Tully limestone; D, Genesee shale; E, Portage; F, Ithaca.

and consequently have fewer falls. In Shurger Glen there are four sets of falls. The first, nearest the lake, about 30 feet high, is caused by the Encrinal beds (limestone); the second, by a hard shale; the third, by the Tully limestone; and the fourth, by the Portage. In Paines Creek near Aurora the Tully and Portage have been eroded away, leaving the Encrinal and the hard calcareous shales of Zone D at Moonshine to form the fall. In the creeks at Farleys the upper hard limestone capping the Marcellus shale, Zone B, forms the falls.

GENERAL GEOLOGY.

The lake section.—In traveling from the village of Cayuga to Ithaca one passes over and can collect from, (1) the Eurypterus beds (Rondout limestone or Waterlime), (2) black gypsum (probably Rondout limestone), (3) Stromatopora beds (Manlius limestone[a]), (4) Oriskany sandstone (this formation has a maximum thickness here of 4 feet 10 inches and thins out to nothing in less than a mile, leaving the Onondaga (Corniferous) in contact with the Lower Helderberg), (5) Onondaga limestone, (6) Marcellus shales, (7) Hamilton shales and impure limestones, (8) Tully limestone, (9) Genesee shale, (10) Portage shales and sandstones. (See fig. 1.)

For the purpose of this paper it will not be necessary to speak more fully of any of the formations mentioned above, with the exception of the Hamilton.

Hamilton formation.—The description of the shales and limestones of the Hamilton formation is given in detail in the description of the different zones which make up this formation. In general it may be said that the Marcellus shales immediately above the Onondaga limestone (where they are very black and fine) alternate with eight or ten layers of impure limestone for a distance of 10 feet. The shale becomes harder and sandy toward the top and closes with a very hard, impure limestone. The Marcellus, as

[a] Memoir New York Mus., Vol. III, No. 3, Oct., 1900, pp. 8–9.

shown by a recent well boring, is 81 feet thick. Above this limestone are the shales of Zone C, several hundred feet thick, which are very soft, with occasionally a harder, more calcareous, or sandy layer, and several courses of concretions. The thick, impure limestone or hard calcareous shale, Zone D, which overlies the soft shales of Zone C, is very marked because of its hardness and richness in fossils. Immediately above this zone and in contact with it is a layer of shale 50 feet thick, as fine and black in the lower part as the Marcellus shale. Above this the calcareous Hamilton shales continue to the Encrinal, becoming somewhat harder as the Encrinal is approached.

Encrinal bed.—The Encrinal is a crystalline limestone about 1½ feet thick. Above this the Upper Hamilton or Moscow shales extend to the Tully limestone. The Upper Hamilton shales vary greatly in hardness and faunal combination.

Concretionary layers.—Concretions appear not far from the Encrinal beds. These concretionary layers are at first shaly, but in the Cayuga Lake section become progresssvely more calcareous as the Tully limestone is approached.

The persistence of the concretionary layers was observed for some distance. One course, which contained *Leiorhynchus laura* and *Orbiculoidea lodiensis media* (Zone V), was observed at Shurger Glen, Lake Ridge, and King Ferry, a distance of 12 miles. These concretions could not be identified in the Seneca Lake section. The thin layer of limestone under the Tully, included in Zone Y, was noted at these places also. Both the limestone layers and the fossils of Zone Y were wanting in the Seneca Lake region. Zone H at King Ferry, containing small upright concretions, with a characteristic fauna, was found also in Paines Creek, 5 miles north. The extent of the Encrinal beds and hard calcareous shales of Zone D is spoken of in another place (pp. 82–83).

Jointing.—The jointing of the rock in this whole region is exceptionally well developed. The joint planes have a direction of N. 20°–30° W. and S. 5°–15° E., and are almost vertical. (See Pl. II.) This jointing accounts, in large measure, for the perpendicular faces of the falls and cliffs which are so noticeable in this region.

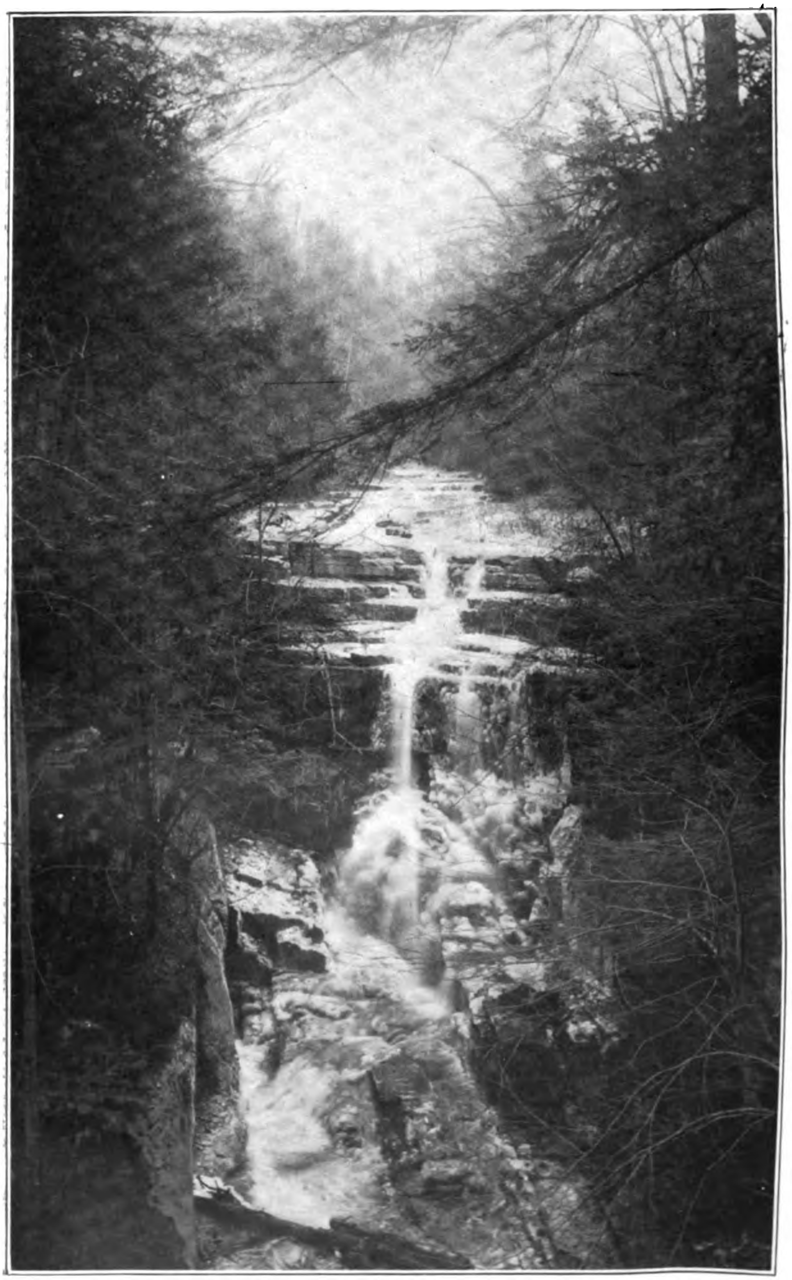
Tully fold.—As one goes up the lake from Union Springs the general dip of the rock to the south is very noticeable, the different strata continuing for some distance and then disappearing under the lake. Using the Tully as a reference plane,[a] it was found that from King Ferry to Lake Ridge the strata descend about 45 feet to the mile. To the south the Tully limestone takes a horizontal position and remains a little above lake level for about 3 miles. It there rises into an arch over 6 miles long, with its highest point at least 235 feet above the lake. From this point south the dip is very rapid, varying from a

[a] Dip of rocks in central New York, by S. G. Williams: Am. Jour. Sci., 3d series, Vol. XXVI, 1883, pp. 303–305.

maximum of 400 feet to the mile, the average being 110 feet. Vanuxem[a] noticed this fold, and explained it as an apparent but not a real fold, reasoning that since the strata dipped southward the bend of the lake to the east would cut into the strata and give the appearance of a fold. The direction and amount of dip of the strata are such that the bend in the lake could not alone have produced such an arch, although it undoubtedly had some effect. The folds along Seneca Lake and the fault in the outlet of Keuka Lake, which are in a west-of-north direction from the Cayuga Lake arch, point to the explanation that this whole region suffered a lateral pressure sufficient to crumple the strata, thus forming a long fold of which the arch at Cayuga Lake and the undulations in the strata at Seneca Lake are a part. The impure limestone of Zone D is so folded that the creek cuts through it twice before it reaches the fall at Moonshine. In Big Gully Creek the limestone which caps the Marcellus shales is cut through by the stream before it reaches the fall; it also makes a fold to the south, forming falls in two small streams.

The fact that the region is not faulted, that the folds are easily seen, and that the creeks cut through the glacial drift into the shales, makes the collecting especially easy, and reduces to the minimum the liability to error in locating the horizons in different sections. The difficulties in the way of making accurate measurements with the instruments at hand were such that all measurements given are only approximate.

[a] Geology of New York. Survey of the third district, 1842.



JOINTING IN UPPER HAMILTON SHALE AT SHURGER GLEN.

The stream falls over Tully limestone.

CHAPTER II.

HISTORY OF THE HAMILTON FORMATION.

McClure.—The first American geologist, William McClure, published a geological map of the United States in the Transactions of the American Philosophical Society in 1809. In this map "he struck out the ground outline of geographical geology."[a] The line separating the "Primitive rocks" from the "Floetz, or secondary," followed the Oneida and Mohawk rivers of New York to the Hudson River. All the country between the Alleghenies and a line running north and south through the western boundary of Arkansas, with the exception of a narrow strip along the Gulf of Mexico, is marked as Floetz, or secondary, and embraces, in a general way, the formations from the Silurian to the Pleistocene.[b]

Eaton.—Amos Eaton after, for that time, considerable travel and observation, published An Index to the Geology of the Northern States in 1820, and later, under the patronage of Stephen Van Rensellaer, made a geological survey of the district adjoining the Erie Canal. These observations he published in 1824.[c]

Werner.—These pioneers in geology were followers of Werner, who attempted to correlate the strata in America with those of Europe as described by the German geologist. As Werner depended entirely upon the lithological character of the strata for his correlations (the value of fossils in correlation not being known at that time) great confusion resulted.

Early attempts at correlation.—Since the Old Red sandstone of England is a conspicuous formation, both McClure and Eaton took it as a convenient reference plane. Eaton first correlated it with the Catskill sandstone (Devonian) and the Triassic sandstone of the Connecticut River. McClure considered the Red sandstone of the Medina group (Silurian) and the Triassic sandstone of the Connecticut River as the equivalent of the Old Red sandstone of Europe. In 1824 Eaton concluded that "the 'Old Red sandstone' rests on the Metalliferous graywacke [Utica and Hudson River group] and underlies the Millstone grit" [Oneida conglomerate of the Medina group]; that is, that the Old Red sandstone (Devonian) should be correlated with a portion of the Medina sandstone, thus placing the greater part of the Upper Silurian and the Devonian in the Carboniferous.

Search for coal.—After the decision was reached that the Red sandstone of the Medina was equivalent to the Old Red sandstone (Devo-

[a] Index to the Geology of the Northern States, by Amos Eaton, 1820, p. viii.
[b] Trans. Am. Philos. Soc., Vol. VI, 1809, pp. 411-428.
[c] Geological and Agricultural Survey of the District adjoining the Erie Canal.

nian) of England which underlies the coal, Eaton expected to find coal in some of the formations in the southern part of the State, and advised the people who lived south of the Medina sandstone to dig for coal wherever there were any indications. Eaton's belief that what we now know to be the Devonian was Carboniferous was strengthened by the finding of thin layers of carbonaceous matter in what, from the localities mentioned, must have been the Marcellus and Genesee shales. This coal in very thin layers is occasionally found in these horizons. Because of this advice a great deal of money was wasted in a vain search for coal.

The different formations of the Devonian were not distinguished by Eaton. The "third graywacke" or "pyritiferous rocks" included all the formations above the Onondaga. His description of this "rock" as a calcareous or siliceous gray rock, with aluminous cement, either slaty or in blocks and rich in fossils, and the localities, the end of Cayuga Lake and the south shore of Lake Erie, between its eastern extension and Sturgeon Point, does not distinguish between the different formations. The Hamilton in the Cayuga Lake locality was not included, as is shown by the fact that the Tully was mistaken for the Onondaga (Corniferous) limestone.

Conrad and Hall.—In 1837 Conrad gave as the object of the New York State survey the stratigraphical and economic study of the various rock formations. The attention of his assistants was directed to the "mineral and fossil contents" of the rock, as the fossils "serve to determine with much accuracy the geological age and character of the strata."

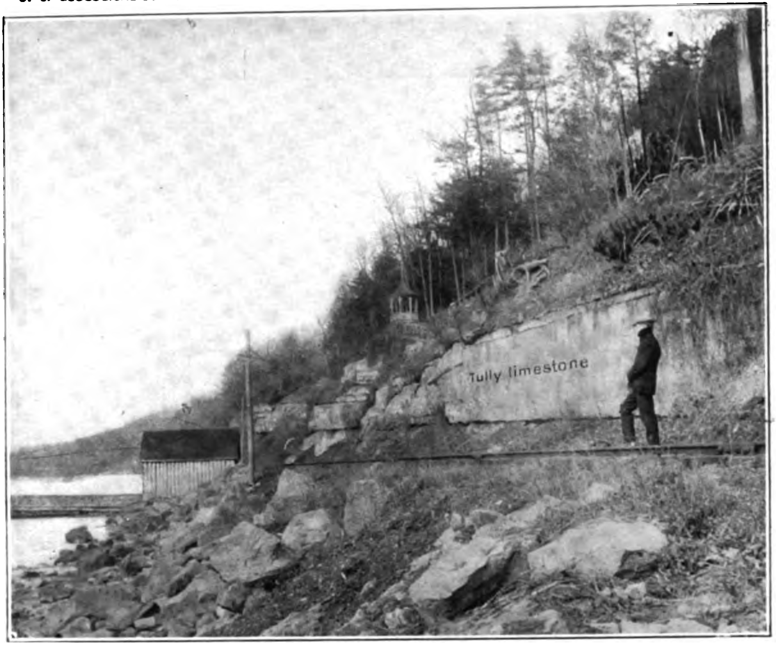
In 1838 Hall considered the rocks of western New York as belonging to the Devonian and Carboniferous. His reason for believing this, he says, rested chiefly on the study of the organic remains, especially of the vertical distribution of the trilobite.[a]

Conrad, in the same report, concluded that the rocks of New York, with the exception of the Catskill, terminated with the Upper Ludlow rocks of Murchison [Upper Silurian].

In the section along the Genesee River, given in the same report, the shales between York and Mount Morris are marked as "limestone shales." This was one of the first attempts to separate the rocks above the Onondaga (Corniferous) in New York State into finer divisions.

In the Fourth Annual Report, 1840, Hall compared the fossils from the New York strata with those of England and correlated the Catskill with the Old Red sandstone [Devonian] of England; the Chemung to Moscow shales [Upper Hamilton], inclusive, with the Upper Ludlow rocks [Upper Silurian]; and the Ludlowville [Lower Hamilton] and Marcellus shales with the Lower Ludlow rocks [Upper Silurian], and adopted the name Ludlowville to show this correlation.

[a] Second Ann. Rept. New York Geol. Survey, 1838, p. 291.



A. TULLY LIMESTONE, SOUTH OF SHURGER GLEN.

B. ENCRINAL BED, SOUTH OF SHURGER GLEN, SHOWING DIP TO THE SOUTH.

The report of 1841 placed the Hamilton (called Sherburn group and shales near Apulia) and Marcellus (called Black shale) in the Aymestry [Upper Silurian]. According to this correlation the "Lower Ludlow rock" closed with the Onondaga (Corniferous) limestone.

Verneuil's correlation.—In his concluding remarks on Verneuil's Parallelism of the Paleozoic Deposits of America with those of Europe,[a] Hall says that the "line of demarcation between the Devonian and Silurian is at the base of the Upper Helderberg or at the bottom of the Schoharie grit. Verneuil proposed to unite the Marcellus shale, Hamilton shale, Tully limestone, and Genesee shale in one division, and make the Portage and Chemung the second of this period. He correlated the Chemung, Portage, Genesee, Tully, and Hamilton with the formations of Eifel and Devonshire; the Marcellus with the shales of Wissenbach in Nassau.

Renevier's correlation.—In the second edition, 1896, of the Tableau des Terrains Sédimentaires formés pendant des Époques de la Phase Organique du Globe Terrestre, by Professor Renevier, the Marcellus and Hamilton are taken together and considered to have been deposited at the same time as the *Tentaculites* shales (lower part) of Thuringia and Bohemia, Wissenbacher slates, and the schists "à Phacops Potieri de Bretagne."

Williams's correlation.—The line separating the Meso- and Eo-Devonian in America was determined by Prof. H. S. Williams to be at the base of the Tully limestone. Previously the Tully had been included in the Meso-Devonian. The reason for this correlation is as follows:[b]

> The conclusions we draw from this study of the faunas of the Cuboides zone and the Tully limestone are that within narrow limits, geologically speaking, the point in the European time scale, represented by the beginning of the deposition of the Cuboides Schichten of Aix la Chapelle, etc., is represented in the New York sections by the Tully limestone, and, second, that the representative of the fauna of the Cuboides zone of Europe is seen in New York not only in the Tully limestone, but in the shaly strata for several hundred feet above. Therefore, if we wish to express precise correlation in our classification of American rocks, the line between Middle and Upper Devonian formations should be drawn at the base of the Tully limestone, to correspond with the usage of French, Belgian, German, and Russian geologists, who include Frasnein, Cuboides Schichten, and correlated zones in the Upper Devonian.

The Meso-Devonian must therefore be considered as bounded above by the Tully and below by the Onondaga (Corniferous).

South American Hamilton.—The sandstone of Erere in Brazil, a portion of the Huamampampa sandstone of Bolivia, and a portion of the formations of the Jachel River in central Argentina are correlated with the New York Hamilton. These correlations were determined chiefly by the presence of *Vitulina pustulosa* and *Tropidoleptus carinatus*.

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[a] Am. Jour. Sci., 2d series, Vol. V, pp. 176-183, 356-370; Vol. VII, pp. 45-51, 218-231.
[b] Williams, Bull. Geol. Soc. America, Vol. I, 1890, pp. 481-500.

CHAPTER III.

DESCRIPTIONS OF THE FOSSILIFEROUS ZONES.

The Hamilton formation, including the Marcellus shales, is in this region, as shown by the Ithaca well section, 1,224 feet thick.[a] It is bounded above by the Tully and below by the Onondaga (Corniferous) limestone.

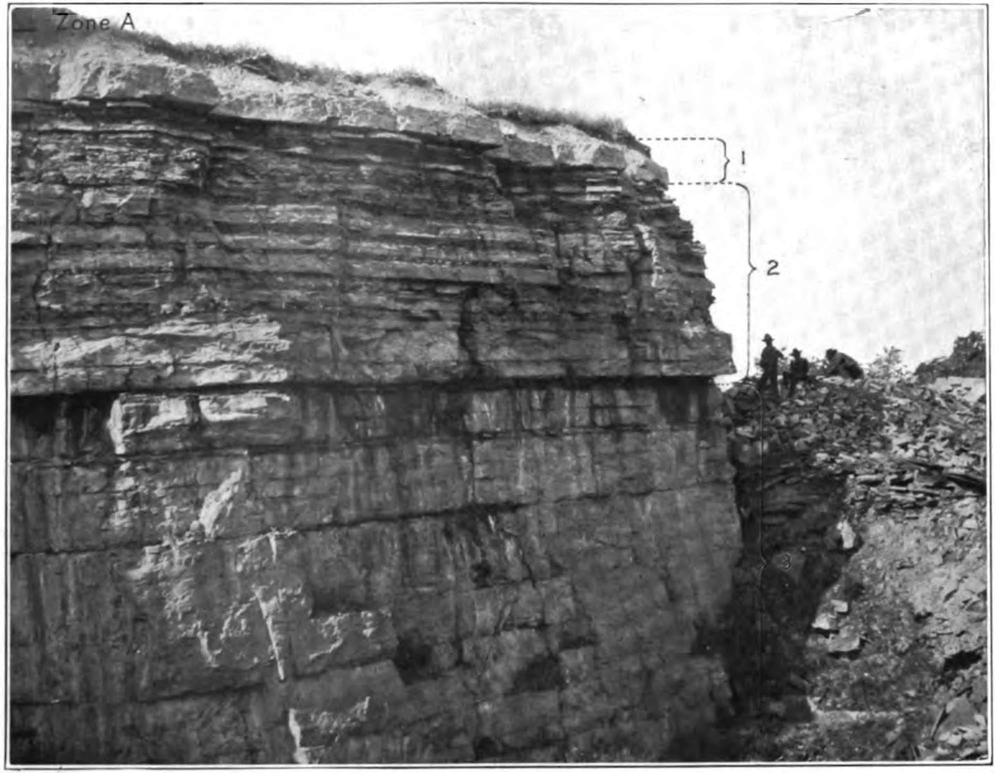
The Cayuga Lake section has been divided into twenty-five zones, each zone having been determined by its contained fauna. When, in working up the section, there seemed to be a change in the fauna or the character of the rock, a provisional division was made, the total number of such divisions being seventy-six. Later, in working up the material in the laboratory, it was found necessary to combine many of these divisions, reducing the number to twenty-five.

The name of each zone is the name of the group, genus, or species which seems especially characteristic of the faunule of that zone. The name chosen is not necessarily that of the most abundant species unless that species is, as far as our present knowledge goes, associated with a definite group of fossils. For example, the three *Leiorhynchus* zones have a faunal resemblance which can not be mistaken, although in the first *Leiorhynchus* zone *Leiorhynchus limitare* is the characteristic species, while in the other two zones the species is *Leiorhynchus laura*. It is also true, that *Leiorhynchus laura* may be associated with an abundance of *Orbiculoidea lodiensis media*, as in Zone V. In the first and second *Ambocœlia umbonata* zones a group of species occurs which is often found associated together when *Ambocœlia umbonata* is abundant. In every zone the fauna is more or less modified by species from lower zones continuing on, and by local conditions, but the essential character of the fauna is determined by the environmental conditions.

A. HAMILTON-ONONDAGA (CORNIFEROUS) ZONE.

Stratigraphy.—This faunule at Cayuga Lake was found in a layer 2 inches thick, almost completely made up of poorly preserved fossils. The shale which held them together was composed of finely comminuted fossils, principally tentaculites. Between this zone and the Onondaga (Corniferous) limestone are eight or ten alternations of impure limestones and fine sooty shale, aggregating 12 feet (see

[a] Prosser, Am. Geologist, Vol. VI, 1890, pp. 199-211.



ALTERNATION OF IMPURE LIMESTONES AND SHALES ABOVE THE ONONDAGA BEDS AT UNION SPRINGS.

Zone A: 1, Goniatite bed; 2, impure limestones and shales; 3, Onondaga limestone.

Pl. IV). Two feet below this zone is a limestone layer (Goniatite limestone), which is purer than any of the layers between it and the

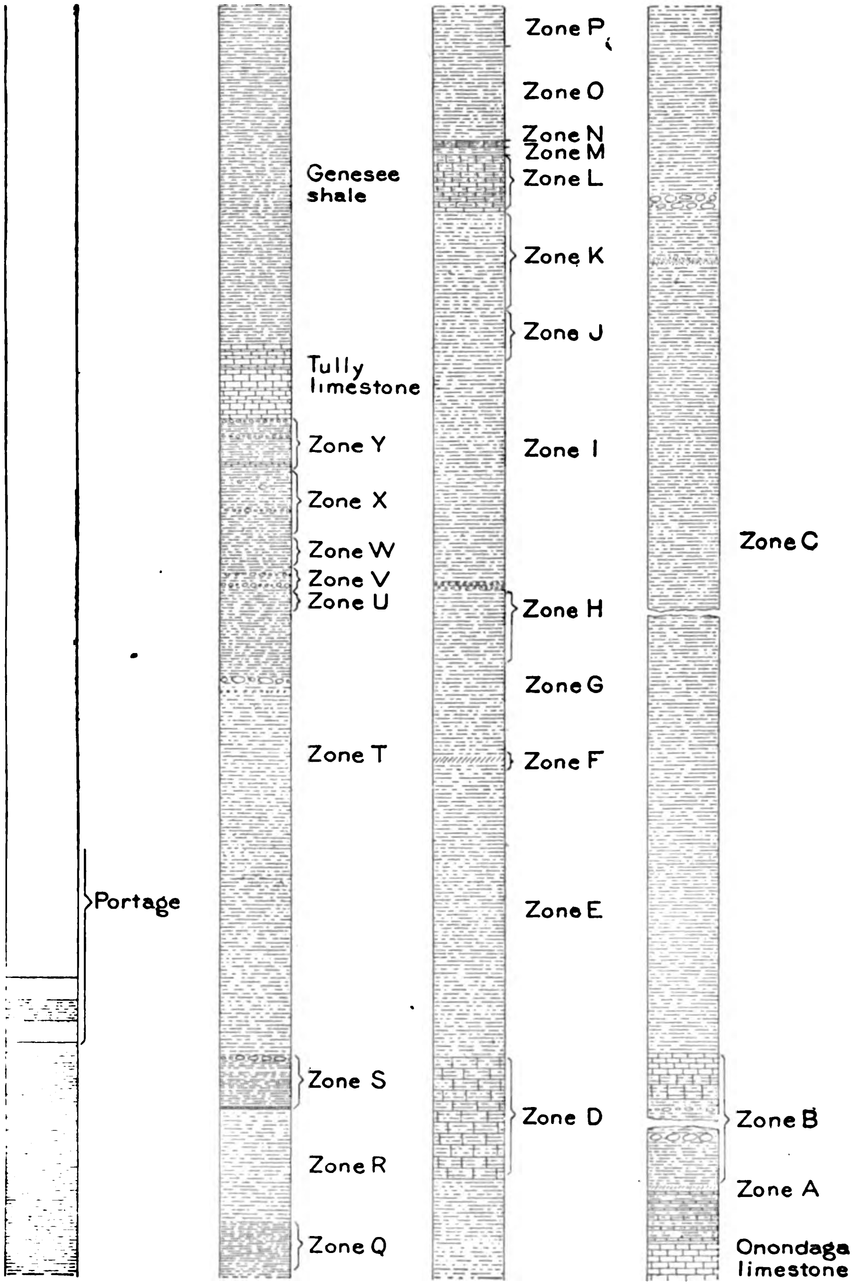


FIG. 2 —Zones in Cayuga Lake section.

Onondaga limestone. Below and above Zone A the shale is very rich in *Styliola fissurella* and *Tentaculites*.

Faunule.—The faunule of this zone is a mixture of Onondaga and Hamilton species, of which Brachiopoda make up the greater part. It contains *Chonetes mucronatus*, *Ambocœlia umbonata*, *Tropidoleptus carinatus*, and other Hamilton species, together with *Spirifer macrus*, *Anoplotheca camilla*, *Chonetes lineatus*, and *Phacops cristata* var. *pipa* of the Onondaga. The absence of *Chonetes coronatus* and *Tropidoleptus carinatus* below this level (12 feet above the Onondaga) shows that the Hamilton must have been developed elsewhere for a long period of time before the deposition of this zone. The fauna is remarkable in that it is not a transition between the Onondaga and Marcellus, but between the Onondaga and Hamilton. Although all the species mentioned, with the exception of *Chonetes coronatus*, have been found in the Marcellus, they are not characteristic of that horizon, but most of them are the common fossils of richly fossiliferous Hamilton zones.

A faunule of similar composition was found in an impure limestone 9 feet above the Onondaga limestone, at Livonia. This faunule contained *Anoplotheca camilla* associated with Hamilton and Onondaga fossils.[a]

Locality.—South of Union Springs, 12 feet above the Onondaga. Layer of gray shale 2 inches thick.

B. FIRST LEIORHYNCHUS ZONE (Marcellus shale).

Stratigraphy.—In the first creek south of Great Gully Creek, in the bed of the stream near the mouth, and in the shale along the lake shore south of this, flattened spherical concretions occur, many being 3 feet in horizontal and 1½ feet in vertical diameter. No fossils were found in them.

The Marcellus shale closes with a hard, impure limestone, 4½ feet thick, which is very noticeable in the creeks in this vicinity, since it forms falls wherever it occurs. It is important in this section, because it makes a distinct line between the shales of the first and second *Leiorhynchus* zones.

With the exception of 2 feet of bituminous shales immediately above Zone A, the Marcellus shales between Union Springs and Great Gully Creek are covered. It is impossible to make an accurate estimate of the thickness of this zone because of the folding of the strata in this region. At Union Springs the Onondaga is folded, and at Great Gully Creek the limestone layer of the Marcellus is so folded that it forms two falls. This same stratum folds to the south, making the rise of ground south of Levanna. The well boring recently made at Ithaca (1900) shows the fine black shale of the Marcellus to be 81 feet thick. It is probable, therefore, that the total thickness is between 80 and 100 feet.

Faunule.—The faunal combination of this zone does not differ materially from that of the second and third *Leiorhynchus* zones with

[a] J. M. Clarke, Forty-seventh Ann. Rept. N. Y. State Mus., pp. 327-352.

the exception of the replacement of *L. limitare* by *L. laura.* In the lower portion of the zone the shale is extremely fine, and the abundance of *Styliola* and *Tentaculites* much greater than in the other *Leiorhynchus* zones. The shales become coarser and the fossils more abundant (with the exception of *Tentaculites* and *Styliola*) as Zone C is approached. The fauna of the upper portion is especially rich in *Orthoceratites.* About 2 feet below the limestone is a nodular layer extremely rich in *Leiorhynchus limitare* in an excellent state of preservation. The shale for 2½ feet below the limestone is very calcareous and coarse, but still contains *L. limitare* and its characteristic fauna.

A *Leiorhynchus* fauna has approximately the following composition:

Leiorhynchus { laura, limitare.	Leiopoteria lævis.
Chonetes { mucronatus, scitulus, lepidus.	Nuculites { triqueter, oblongatus.
(Orbiculoidea media).	Nucula corbuliformis.
Strophalosia truncata.	Styliola fissurella.
Lunulicardium fragile.	Tentaculites.
	Phacops rana.

Locality.—Near the mouth of the creeks between Levanna and Farleys. The best exposure for the upper portion is in Great Gully Creek; for the lower, the quarries south of Union Springs.

C. SECOND LEIORHYNCHUS ZONE.

Stratigraphy.—This zone is quite uniform in its lithological and faunal characters with the exception of one layer of dark calcareous shale about 15 feet above the Marcellus shale, which contains a greater number of *Phacops rana* and *Ambocœlia umbonata* than is usual elsewhere in the section. As a rule the shale is fine and seldom contains more than eight or nine species to each 5 feet. Two courses of concretions occur 70 feet below Zone D. Occasionally a harder layer occurs; but, with the exception mentioned, the species do not change with this slight change in sedimentation. The lower and upper portions of this zone were worked more carefully than the middle portion.

Faunule.—This zone, which is several hundred feet thick, is very poor in fossils. The faunule is one which usually occurs in the fine shales of the Hamilton stage where the conditions were not favorable to a rich Hamilton faunule. The make-up of the fauna is given under Zone B. This same faunule is reported from the Livonia section.

Localities.—Paines Creek, south of Aurora, from Moonshine Falls to the lake; Deans Creek, north of Aurora, from Goulds Falls to the lake; Great Gully Creek, south of Union Spring, to the Marcellus shale. It is also finely developed in the Seneca Lake section.

D. FIRST TEREBRATULA ZONE (Basal limestone of Clarke).

Stratigraphy.—Because of its hardness, compared with the soft shales above and below, this zone forms a fall in all of the creeks

where it appears. Moonshine Falls, on Paines Creek, and the fall in Deans Creek, on the farm of James Gould, are from 30 to 40 feet high. The rock is a hard calcareous shale, almost an impure limestone. The fauna as well as the lithological character separates this zone sharply from the shales above and below. It is 25 feet thick in Paines Creek.

Faunule.—The genera of this section are not, by any means, the most common fossils in this zone; but since they are associated with a peculiar combination of species, both here and at Eighteenmile Creek, the name *Terebratula* has been used to designate that combination. The combination of species spoken of above is *Cryptonella planirostris*, *C. rectirostris*, *Meristella haskinsi*, *Eunella lincklæni*, *Spirifer divaricatus*, *Vitulina pustulosa*, and in the Encrinal, in addition or by substitution, *Centronella impressa*.

This is the first and only zone in which *Heliophyllum halli* appeared in any numbers. The locality was, however, especially favorable for collecting, on account of the great area of the zone exposed by the folding of the strata and the consequent wearing away of the soft upper shales in several places by the action of the water. One specimen of *H. confluens* was obtained from the Encrinal beds at Black Rock, on Paines Creek, and one specimen of *H. halli* from a doubtful locality in the Upper Hamilton. With these exceptions no specimens of this genus were found above or below Zone D. *Vitulina pustulosa* is common, and was found in the same abundance in the Encrinal beds, but not elsewhere in the section.

The shale of this zone is extremely fossiliferous. The total number of species found was 84; of these, 32 are Pelecypoda, 33 Brachiopoda, 4 Gasteropoda, 3 trilobites, 3 corals.

Localities.—Paines and Deans creeks on the east side of Cayuga Lake; Slate Rock Run on west side of Seneca Lake. D. F. Lincoln[a] reports it from Bentons Run, west side of Seneca Lake; north of Days Landing; Reeders Creek; West Fayette station; 1 mile west of West Bearytown; 1 mile southeast of Bearytown; Big Hollow Creek east of Romulus. Clarke reports it from Canandaigua Lake and Flint Creek.

NOTE.—This zone is well exposed in Slate Rock Run on the west side of Seneca Lake. In this locality it is 15 feet thick and contains a faunule very similar to that of the Cayuga Lake region. The principal difference noted was the greater abundance of cyathophylloid and Favosite corals. The common fossils of this zone in Slate Rock Run are:

Heliophyllum halli.	Eunella lincklæni.
Cystophylum americanum.	Rhipidomella vanuxemi.
Favosites.	Crinoid stems.
Chonetes mucronatus.	Stropheodonta inæquistriata.

[a] Ann. Rept. State Geol. New York, 1884.

103. Grammysia cuneata Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 383, pls. 62 and 93.

This species, like all species of *Grammysia*, is far from common in any portion of the section.

104. Grammysia arcuata Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 373, pls. 61, 63, and 93.

Ten or 15 feet below the Encrinal this species is quite common, elsewhere it is rare. Three valves (one of which measures fully 80 mm. in length) from Zone Y answer the description of *G. subarcuata* of the Chemung fairly well, but were included in *G. arcuata*.

105. Grammysia bisulcata Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 359, pls. 56 and 93.

A few specimens of this species were found in Zone G. It is reported from the upper 160 feet of the Upper Hamilton at Livonia.

Genus ELYMELLA Hall.

106. Elymella fabalis Hall.

Pal. N. Y., vol, 5, pt. 1, 1885, p. 502, pl. 40.

Two valves from Zone Y are referred to this species. The anterior end is rather too long for *E. fabalis*, but may be a variation.

107. Elymella nuculoides Hall.

Pal. N. Y., vol. 5, pt. 1, p. 503, pl. 40.

A few specimens of this species were found in Zone X.

Genus GLOSSITES Hall.

108. Glossites subtenuis Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 495, pl. 40.

There is some doubt as to the correctness of the identification of the specimen referred to this species.

Genus TELLINOPSIS Hall.

109. Tellinopsis subemarginata Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 464. pl. 76.

This species is common in Zone X, the center of Zone T, Zone J, Zone G, and the lower portion of Zone D. It is never abundant and seldom common, but is found in almost all the zones in this section.

At Eighteenmile Creek a single specimen was found. It is reported from four zones in the Upper Hamilton of the Livonia section.

Two large specimens were 45 and 30 mm. long and 27 and 17 mm. wide.

Family CARDIOLIDÆ Neumayr.

Genus PANENKA Barrande.

110. Panenka lincklæni Miller.

Pal. N. Y., vol. 5, pt. 1, p. 420, pl. 69.

The specimen which was referred to this species is probably a new species. It differs from *P. lincklæni* in the broad concave plications, the almost flat interspaces, and the absence of intermediate radii. Both plications and interspaces are crossed by fine concentric lines. Found in Zone T.

111. Panenka potens Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 422, pl. 69.

A very imperfect specimen about 60 mm. in height is doubtfully referred to this species. It was found associated with *Lunulicardium curtum* and *L. ornata* in Zone C.

112. Panenka sp. undet.

A small, well-preserved cast of a *Panenka* from Zone X does not answer the description given in the New York Paleontology. It is about 12 mm. high and of the same length. The plications number 22 and reach the beak. Faint concentric lines can be seen. This specimen bears a resemblance to *P. retusa*, which is reported from Cayuga Lake. The plications of *P. retusa*, however, number 35, with narrow interspaces, while the size is 30 mm. in length and 31 mm. in height.

Genus GLYPTOCARDIA Hall.

113. Glyptocardia speciosa Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 426, pls. 70 and 80.

This species is found occasionally in Zones T, F, and E; elsewhere in the section it is very rare or wanting. The largest specimen from Zone F measured 11 mm. in height. It is not reported from Eighteen-mile Creek or Livonia.

Superfamily NUCULACEA.

Family (?) CTENODONTIDÆ Dall.

Genus NUCULITES Conrad.

114. Nuculites triqueter Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 326, pls. 47 and 93.

This species is common throughout the section, except where the shales are calcareous, as in the Encrinal bed, Zone D and Zone G. The variations in form are not progressive. It is not uncommon at Livonia, but was not found above the Marcellus shale at Eighteen-mile Creek.

115. Nuculites oblongatus Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 324, pl. 47.

What has been said regarding the distribution of *N. triqueter* in the Cayuga Lake section is true of *N. oblongatus*. The conditions which were favorable to one were favorable to the other.

At Eighteenmile Creek it is rare in the only zone in which it occurs.

Family NUCULIDÆ Adams.

Genus NUCULA Lamarck.

116. Nucula varicosa Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 319, pls. 46 and 93.

This is a very variable species, the extremes of which are often difficult to classify. It is one of the rarer nuculas.

117. Nucula randalli Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 315, pls. 45 and 93.

A small *Nucula* from Zone I was referred doubtfully to this species.

118. Nucula lirata Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 316, pls. 45 and 93.

This is a common species in the Upper but is not often found in the Lower Hamilton in this section. It is reported from two zones in the Upper Hamilton at Livonia. It does not occur at Eighteenmile Creek.

119. Nucula bellistriata Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 318, pl. 46.

This species is so closely related to *N. varicosa* that in some cases it is difficult to distinguish between them. It is not uncommon between Zone D and the Tully limestone, but is never abundant.

120. Nucula corbuliformis Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 319, pl. 46.

This is more common and has a greater vertical distribution than any other *Nucula* in the section. It is found throughout the Marcellus and Hamilton shales along Cayuga Lake. Unlike the Brachiopoda, it is present in almost every zone except those which are very calcareous, as the Encrinal, and, although it is never exceptionally abundant in the aggregate, the number of individuals is very great.

Family LEDIDÆ Adams.

Genus LEDA Schumacher.

121. **Leda rostellata** Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 330, pl. 47.

This species is common in the *Stropheodonta*-Coralline zone, but is rare elsewhere in the section. It was not found in the Marcellus shales or Zone C. It is not reported from Livonia or Eighteenmile Creek.

122. **Leda brevirostris** Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 329, pl. 47.

Specimens from Zone Y were referred to this species.

Genus PALÆONEILO Hall.

123. **Palæoneilo constricta** Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 333, pls. 48 and 51.

P. constricta is a common and sometimes an almost abundant species throughout the greater portion of the section above Zone D. It was also found in the upper part of Zone C. Its greatest abundance is in Zone T.

124. **Palæoneilo emarginata** Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 338, pl. 50.

This strongly marked species is common in Zone W, in the lower part of Zone T, and in Zone I; elsewhere in the section it is very rare.

125. **Palæoneilo plana** Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 334, pl. 48.

This species was not found below Zone R. It is quite common in Zone W and in the upper part of Zone T.

126. **Palæoneilo maxima** Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 335, pl. 48.

A single specimen from Zone Y was referred to this species. It measured 34 mm. in length by 19 mm. in height.

127. **Palæoneilo muta** Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 337, pl. 49.

This species was found only in the Upper Hamilton, and then but rarely. Three specimens measured 19, 16, and 10 mm. in length and 11, 8, and 5 mm. in height, respectively.

128. Palæoneilo fecunda Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 336, pl. 49.

This is a rare species in this section. With the exception of a single specimen from Zone I, it is only found, and rarely, in the Upper Hamilton.

129. Palæoneilo tenuistriata Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 336, pls. 49 and 93.

This species is restricted to a narrow zone in the Upper Hamilton of which Zone W is the center. One specimen, which retains a portion of the shell, shows radiating lines apparently due to the original color of the shell. Other specimens show faint radiating lines.

Family PARALLELODONTIDÆ Dall.

Genus PARALLELODON Meek.

130. Parallelodon hamiltoniæ Hall.

(*Macrodon hamiltoniæ*) Pal. N. Y., vol. 5, pt. 1, 1885, p. 349, pl. 51.

This species is quite common from Zone D to the Tully limestone. It was found in Zones B and C.

(?) Genus SPHENOTUS Hall.

131. Sphenotus arcæformis Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 395, pls. 65 and 66.

A small specimen of this species from Zone K measured 9 mm. in length and 4 mm. in height. The normal size is 26 to 32 mm. in length and 12 to 14 mm. in height.

132. Sphenotus cuneatus Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 396, pl. 65.

Four well-marked specimens of this species were found in Zone G. The specimens measured 19, 15, 16, and 6 mm. in length and 9, 8, 8, and 4 mm., respectively, in height.

133. Sphenotus solenoides Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 398, pl. 45.

This is a rare species in this section. It was found in Zones D and L.

Superfamily PTERIACEA Dall.

Family PTERINEIDÆ Dall.

Genus PTERINEA Goldfuss.

134. Pterinea flabella Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 93, pls. 14 and 15.

This species was not found in the Upper Hamilton and is very rare in the Lower Hamilton, being common in no zone. At Eighteenmile Creek it is found commonly a few feet below the Encrinal beds, but is not reported above.

Family LUNULICARDIIDÆ Fischer.

Genus LUNULICARDIUM Münster.

135. Lunulicardium fragile Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 434, pl. 71.

This species, with the exception of Zone D, is not uncommon between Zones A and G. Above Zone G it is rarely found. At Eighteenmile Creek it is reported from but one zone above the Marcellus shale. At Livonia it is a common fossil below the Encrinal, and is abundant in one zone of the Upper Hamilton.

136. Lunulicardium curtum Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 437, pl. 71.

This occurs rarely in the shales of Zone C and the Marcellus.

137. Lunulicardium ornatum Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 437, pl. 71.

This species was found in the upper part of Zone C.

Family AMBONYCHIIDÆ Miller.

Genus PLETHOMYTILUS Hall.

138. Plethomytilus oviformis Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 255, pls. 31 and 87.

This species was found in Zones I, F, X, and Y. The specimens measured 62, 32, and 8 mm. in height, and 50, 26, and 6 mm. in length. At Eighteenmile Creek it is restricted to the upper Encrinal beds.

Genus MYTILARCA Hall.

139. Mytilarca gibbosa Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 262, pls. 33 and 87.

The specimen which was referred provisionally to this species is about midway between *M. gibbosa* and *M. simplex* in form. It measures 35 mm. in height and 24 mm. in length.

Genus SPATHELLA Hall.

140. Spathella typica Hall.

Pal. N. Y., vol 5, pt. 1, 1885, p. 407, pl. 66.

This specimen is 28 mm. in length and 14 or 15 mm. in height. It is slightly crushed dorso-ventrally. The concentric lines are strong, with occasional finer concentric striæ between.

Family CONOCARDIIDÆ Neumayr.

Genus CONOCARDIUM Bronn.

141. Conocardium normale Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 411, pl. 68.

A single specimen of this genus was found in Zone I. The surface markings on the posterior and the anterior expansion of the shell along the edge of the umbonal ridge can be made out.

Family PTERIIDÆ Meek.

Subgenus ACTINOPTERIA Hall.

142. Actinopteria boydi Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 113, pls. 19 and 84.

This is a rare fossil in this section. It is found occasionally in the limy shales of Zones Y and D.

143. Actinopteria decussata Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 111, pls. 17, 18, 20, and 84.

A few specimens of this species were found in the Upper Hamilton.

144. Actinopteria subdecussata Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 110, pls. 17 and 19.

A single specimen was found in Zone T.

Genus LEIOPTERIA Hall.

145. Leiopteria greeni Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 160, pls. 20 and 88.

A single specimen of this species was found in Zone L. It measured 38 mm. in height and 32 mm. along the hinge line.

146. Leiopteria lævis Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 158, pls. 17 and 20.

This species is common in the Upper Marcellus, seldom found in Zone C, and occasionally in the shales above Zone D.

147. Leiopteria rafinesquii Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 161, pls. 15, 20.

Specimens from Zones J and D belong to this species.

148. Leiopteria gabbi Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 169, pl. 88.

One individual of this species was found in Zone C. One from Zone T was referred to it with some doubt.

149. Leiopteria sayi Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 162, pl. 88.

This species is rather common in Zone T, but not elsewhere in the section. It is associated with *L. lævis*.

150. Leiopteria conradi Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 159, pls. 20 and 88.

A number of specimens from Zones D and T were of this species. A number of intermediate forms were included.

151. Leiopteria dekayi Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 164, pls. 19, 20, 88.

One specimen from Zone T was of this species. It was not perfect, but the obliqueness of the form, which is very characteristic of *L. dekayi*, is quite pronounced.

Family MYALINIDÆ Frech.

Genus MODIELLA Hall.

152. Modiella pygmæa Conrad.

Pal. N. Y., vol. 5, pt. 1. 1885, p. 514, pl. 76.

This species is found occasionally in Zone C and is one of the common fossils from Zone D to within a foot of the Tully limestone. It reaches its greatest abundance in Zone T. It has very much the same habit as *Nuculites oblongatus* and *N. triqueter*. Although seldom common, it is almost always present except in very limy sediments.

Superfamily TRIGONIACEA Bronn.

Family TRIGONIIDÆ Lamarck.

Genus SCHIZODUS King.

153. Schizodus appressus Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 449, pl. 75.

This is a rare species, but is not confined to any one zone.

154. Schizodus contractus Hall.

Pal. N. Y., vol. 5, pt. 1, p. 451, pl. 75.

Specimens of this species were found in the shales immediately under the Tully limestone and in Zone D. Between these zones it is wanting. One individual measured 4 mm. in height and 7 mm. in length.

Superfamily PECTINACEA Reeve.

Family PECTINIDÆ Lamarck.

Genus AVICULOPECTEN McCoy.

155. Aviculopecten princeps Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 1, pls. 1, 5, 6, 24, and 81.

This species is from the upper and lower portions of the Upper Hamilton. It seemed to thrive best in calcareous sediments. One right valve had markings similar to those shown in pl. 81, fig. 16. It was found in six zones at Eighteenmile Creek.

156. Aviculopecten fasciculatus Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 11, pls. 5 and 81.

One imperfect specimen from Zone D was doubtfully referred to this species.

157. Aviculopecten scabridus Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 7, pl. 3.

A very much distorted specimen with the characteristic surface markings was found in Zone G.

Subgenus Pterineopecten Hall.

158. Pterineopecten undosus Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 72, pls. 2 and 82.

This species is restricted to the Upper Hamilton and the upper 50 feet of the Lower Hamilton. It is nowhere common, and varies greatly in shape and surface markings.

159. Pterineopecten vertumnus Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 71, pls. 5 and 83.

This species is found in three zones, only one specimen being found in each.

160 Pterineopecten intermedius Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 68, pls. 17 and 83.

This species is slightly commoner than the preceding species of *Pterineopecten*, and is found in a number of zones from Zone D to the Tully.

161. Pterineopecten hermes Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 64, pl. 17.

This is a well-marked but variable species, and when poorly preserved often resembles *P. intermedius*.

Subgenus LYRIOPECTEN Hall.

162. Lyriopecten orbiculatus Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 42, pls. 4 and 82.

A specimen from Zone D was referred with considerable certainty to this genus and species.

Superfamily MYTILACEA Ferussac.

Family MODIOLOPSIDÆ Fischer.

Genus MODIOMORPHA Hall.

163. Modiomorpha subalata Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 283, pls. 35 and 39.

This species is not uncommon in Zones J, F, and the upper part of C. Four specimens measured, respectively, 19, 21, 24, and 32 mm. in length and 11, 12, 15, and 18 mm. in height. It is a common species in the Lower Hamilton at Eighteenmile Creek.

164. Modiomorpha concentrica Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 275, pls. 34, 35, 36.

This is the commonest *Modiomorpha* at Cayuga Lake. It is distributed from Zone D to the uttermost zone in the Hamilton. It is common in Zones H, O, T, and X. At Eighteenmile Creek it is common in the Encrinal and is found occasionally in the Lower, but does not occur in the Upper Hamilton.

165. Modiomorpha mytiloides Conrad.

Pal. N. Y., vol. 5, pt. 1, p. 277, pls. 37 and 38.

This species is far from being common, but is found occasionally in Zone D and above. It is common in three zones above the Encrinal at Livonia, but it is not reported from Eighteenmile Creek.

166. Modiomorpha alta Conrad.

Pal. N. Y., vol. 5. pt. 1, 1885, p. 278, pls. 37, 80.

Two small specimens from Zone X were referred to this species. A number of specimens which seem to be of a new species have been placed in this species. The measurements of these were 25, 18, 15, 10, and 4 mm. in length and 16, 11, 11, 7, and 5 mm. in height.

Genus GONIOPHORA Phillips.

167. Goniophora hamiltonensis Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 296, pl. 43.

This species is found rarely in eight zones, commencing with the first *Terebratula* zone (D), to the Tully limestone.

168. Goniophora truncata Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 298, pls. 42 and 44.

This well-marked species was found in Zones S and Y. Only one specimen was found in each zone and both were badly crushed.

169. Goniophora rugosa Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 297, pls. 42 and 43.

A few specimens of this species were found between Zone D and the Tully limestone. Two specimens measured 40 and 45 mm. in length and 26 and 28 mm. in height, respectively.

170. Goniophora glaucus Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 299, pls. 43 and 44.

A single badly crushed specimen from Zone Y was referred to this species with doubt.

Order ANOMALODESMACEA Dall.

Superfamily ANATINACEA Dall.

Family PHOLADELLIDÆ Miller.

Genus PHOLADELLA Hall.

171. Pholadella radiata Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 469, pls. 78 and 96.

This species was not found in the Marcellus shales nor in Zone C, but is scattered throughout the remainder of the section. It occurs frequently in the upper shales of the Lower Hamilton and is almost abundant in Zone O.

Three specimens measured 25, 7 and 5 mm. in length and 13, 4, and 2 mm. in height, respectively.

172. Pholadella parallela Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 470, pl. 78.

This well-marked species was found in Zone T. It is rare in this zone and was not obtained elsewhere in the section.

Genus CIMITARIA Hall.

173. Cimitaria corrugata Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 465, pl. 77.

This species was found in Zones Y and H, but was not seen elsewhere in the section.

174. Cimitaria elongata Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 466, pl. 77.

Two specimens of this species were obtained from the Encrinal band at King Ferry.

Order TELEODESMACEA Dall.

Superfamily CYPRICARDIACEA Dall.

Family PLEUROPHORIDÆ Dall.

Genus CYPRICARDELLA Hall.

175. Cypricardella bellistriata Conrad.

(*Microdon bellistriatus*) Pal. N. Y., vol. 5, pt. 1, 1885, p. 308, pls. 42, 73, 74.

This species is common in the upper part of the Upper Hamilton and in the upper portion of the Lower Hamilton; in the latter it is almost abundant. Aside from these two zones the species is quite rare in this section.

At Eighteenmile Creek it was not found above the Encrinal and, with the exception of one zone at the base of the Hamilton, is very rare throughout the section. One very large specimen from the Encrinal bed on Paines Creek measured 60 mm. in length and 38 mm. in height.

Genus CYPRICARDINIA Hall.

176. Cypricardinia indenta Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 485, pls. 79 and 96.

This species is common in two zones, in Zone X and the middle third of Zone D.

Specimens measured 14, 9, and 7 mm. in length and 8, 5, and 4 mm. in height, respectively. It is a Lower Hamilton fossil at Eighteenmile Creek.

Superfamily LUCINACEA Anton.

Family LUCINIDÆ Fleming.

Genus PARACYCLAS Hall.

177. Paracyclas tenuis Hall.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 443, pls. 72 and 95.

This species is rather common in three zones of the Upper and in one zone of the upper part of the Lower Hamilton. It varies greatly in size and in the strength of its concentric striæ, but is readily distinguished from the other species of this genus. It is not reported from Eighteenmile Creek or Livonia.

178. Paracyclas lirata Conrad.

Pal. N. Y., vol. 5, pt. 1, 1885, p. 441, pls. 72 and 95.

Only two small valves of this species were found. They measured about 7½ mm. in height by 8 mm. in length.

Class GASTEROPODA.

The Gasteropoda were not found to be of much value in this faunal study. They are never common, but are found occasionally in almost all of the zones.

Subclass STREPTONEURA Spengel.

Order ASPIDOBRANCHIA Schweigger.

Suborder RHIPIDOGLOSSA Troschel.

Family PLEUROTOMARIIDÆ d'Orbigny.

Genus PLEUROTOMARIA de France.

179. Pleurotomaria itys Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 76, pl. 20.

As with the other species of the genus, *P. itys* is not common in nor charactistic of any zone. It occurs throughout the section. At Eighteenmile Creek it is found only at the base of the Hamilton.

180. Pleurotomaria capillaria Conrad.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 77, pl. 20.

It is often difficult to distinguish the extremes of this species from the above unless the specimens are well preserved. Quite generally distributed throughout the section. Confined to the base of the Hamilton at Eighteenmile Creek.

181. Pleurotomaria trilix Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 79, pl. 21.

Found rarely in the Upper Hamilton at Cayuga Lake.

182. Pleurotomaria sulcomarginata Conrad.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 69, pl. 19.

Two specimens of this species were obtained from the upper part of the Upper Hamilton, Zones W and T.

183. Pleurotomaria rotalia Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 71, pl. 19.

Two specimens from Zone T were of this species.

184. Pleurotomaria rugulata Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 75, pl. 20.

This species is met with occasionally in Zone C, in the Marcellus shales, and in Zone D. The specimens are all very much crushed or in the form of molds, and the surface markings are indistinct.

Family BELLEROPHONTIDÆ McCoy.

Genus BELLEROPHON de Montfort.

185. Bellerophon patulus Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 100, pls. 22 and 24.

This species is not uncommon in Zones X and N; elsewhere it is rare. It was not found below Zone C. The specimens obtained were of the usual size, but badly crushed.

186. Bellerophon leda Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 110, pl. 23.

This is the most common Bellerophon in the section. It is almost common in some of the thin layers of Zone C. It is common in the lower portion of the Lower Hamilton at Eighteenmile Creek.

187. Bellerophon lyra.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 113, pl. 23.

Only a few specimens of this species were found in the section.

188. Bellerophon crenistria Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 116, pl. 25.

A few specimens of this species were obtained in six zones of the Upper and Lower Hamilton.

Genus CYRTOLITES Conrad.

189. Cyrtolites mitella Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 123, pl. 25.

Only a few specimens of this species were obtained. None were found lower than Zone D.

Family EUOMPHALIDÆ de Koninck.

Genus EUOMPHALUS Sowerby.

190. Euomphalus sp.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 54.

A single crushed specimen from Zone O was referred to this genus. The specific characters could not be made out.

Order CTENOBRANCHIATA Schweigger.

Suborder PLATYPODA.

Superfamily TÆNIOGLOSSA Bouvier.

Family CAPULIDÆ Cuvier.

Genus PLATYCERAS Conrad.

191. Platyceras conicum Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 3, pl. 1.

A single large specimen was found in the Encrinal beds.

192. Platyceras erectum Hall

Pal. N. Y., vol. 5, pt. 2, 1879, p. 5, pl. 2.

This gastropod was found most commonly in the upper portion of the Encrinal and in the limestone of Zone Y. Elsewhere it is rare.

193. Platyceras bucculentum Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 10, pl. 3.

Typical specimens of this species were found in Zones Y and S.

194. Platyceras carinatum Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 5, pl. 2.

Specimens having the characteristic shape of this species were found in Zones W and Y.

Genus PLATYOSTOMA Conrad.

195. Platyostoma lineata Conrad.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 21, pl. 10.

This species was found in a number of zones, but was not common in any. It possesses, in all cases, the characteristic surface markings.

196. Platyostoma varians Hall.

(*Strophostylus*) Pal. N. Y., vol. 5, pt. 2, 1879, p. 31, pl. 11.

A large specimen from Zone J and eight smaller ones from Zone C were referred to this species with some doubt. The larger specimen is typical; the smaller ones are small, and may be of a new species.

Superfamily GYMNOGLOSSA.

Family PYRAMIDELLIDÆ Gray.

Genus LOXONEMA Phillips.

197. Loxonema hamiltoniæ Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 45, pl. 13.

This species occurs throughout the entire section. It is often difficult to distinguish it from *L. delphicola* when the specimens are imperfect. At Eighteenmile Creek this species and *L. delphicola* are restricted to the Upper Marcellus shales.

198. Loxonema delphicola Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 47, pls. 13 and 14.

This species is frequently met with in the section above Zone D. It is commoner than *L. hamiltoniæ*. Very often the shell is surrounded by a "smooth, polished shale (slickensides)," as is figured by Hall in figs. 24 and 25 of the above report.

Superfamily PTENOGLOSSA Gray.

Family SCALARIIDÆ Broderip.

Genus CALLONEMA Hall.

199. Callonema imitator Hall and Whitfield.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 53, pl. 14.

One specimen, 50 mm. in diameter, with the surface marked by strong elevated striae gently curving backward and increasing in strength from the apex to the last volution, was found in Zone N. The coil is rather loose.

Order OPISTHOBRANCHIA Milne-Edwards.

Suborder PTEROPODA Cuvier.

Family CAVOLIINDÆ Fischer.

Subgenus STYLIOLA Lesueur.

200. Styliola fissurella Hall.

Pal. N, Y., vol. 5, pt. 2, 1879, p. 178, pl. 31A.

It will be noticed in the table of species that *S. fissurella* is very rare, almost wanting, in the Upper Hamilton; that between Zone D and the Encrinal, with the exception of the fine shales of Zone E, it is also very rare, and that in the fine shales of Zone C and in the Marcellus shales it is very common. In the lower portion of the Marcellus shales the *Styliola* is beautifully preserved in pyrite. It is very abundant in certain layers in the Marcellus shales. At Eighteenmile Creek it is very common in a number of zones of the Lower and is fairly common in the uppermost zone of the Upper Hamilton.

Suborder CONULARIDA Miller and Gurley.

Family TENTACULITIDÆ Walcott.

Genus TENTACULITES Schlotheim.

201. Tentaculites bellulus Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 169, pls. 31 and 31A.

A specimen of this species was obtained from Zone X. In Zone A there are great numbers of *Tentaculites*, but in such a poor state of preservation that it is impossible to make a specific identification.

Family TORELLELLIDÆ Holm.

Genus COLEOLUS Hall.

202. Coleolus tenuicinctum Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 185, pls. 32 and 32A.

A number of very good specimens of this species were found in various parts of the section.

Family HYOLITHIDÆ Nicholson.

Genus HYOLITHES Eichwald.

203. Hyolithes aclis Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 197, pls. 32 and 32A.

Although this is a rare species at Cayuga Lake, in the aggregate the number found is quite large. The variations consist in the relative difference in length, width, and thickness. The measurements are 30, 30, 25 mm. in length and 9, 11, and 12 mm. in width. Two well-preserved operculæ were found.

204. Hyolithes striatus Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 199, pl. 32.

A specimen with well-marked longitudinal lines was found in Zone T.

Genus CONULARIA Miller.

205. Conularia undulata Conrad.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 208, pls. 33 and 34A.

A fragment of a large specimen of this species with very strong surface markings was found in Zone D. A fragment of a smaller individual was taken from Zone I.

Class CEPHALOPODA.

Subclass TETRABRANCHIATA Owen.

Order NAUTILOIDEA.

Suborder ORTHOCHOANITES Hyatt.

Family ORTHOCERATIDÆ.

Genus ORTHOCERAS Breynius

206. Orthoceras crotalum Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 296, pls. 42, 82, and 93.

This fossil is found occasionally throughout the section above Zone D. The test is often denuded, making the identification in some cases uncertain.

207. Orthoceras cælamen Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 298, pls. 42, 43, 82, 113.

A few specimens with the characteristic surface marking were obtained from the Upper Hamilton shales.

208. Orthoceras nuntium Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 299, pls. 43 and 82.

This is a rare fossil in this section. Two specimens were found in the Upper Hamilton.

209. Orthoceras subulatum Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 283, pls. 38, 84, 86.

This species of *Orthoceras* is not uncommon along Cayuga Lake. A large number of distorted specimens of this genus were referred here with some doubt. One specimen showed the surface markings.

210. Orthoceras constrictum Vanuxem.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 288, pls. 84, 85.

This is a rather rare species in this section, and is not reported west of Cayuga Lake.

211. Orthoceras exile Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 290, pls. 39, 84, 85.

A few specimens were doubtfully placed in this species.

212. Orthoceras marcellense Vanuxem.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 278, pls. 38, 83, and 113.

A specimen from the Marcellus seems to be of this species.

213. Orthoceras, sp. undet.

This genus, as a whole, is common between Zones B and F, inclusive, and in Zone T. Elsewhere in the section this genus was rare.

Family NAUTILIDÆ.

Genus NAUTILUS Breyn.

214. Nautilus liratus juvenis Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 411, pl. 56.

James Hall describes this variety of *N. liratus* from an imperfect specimen and states that the determination is quite unsatisfactory. Two fairly well-preserved specimens from the hard shales of the upper Marcellus are certainly distinct from *N. liratus* and answer to the description of *N. liratus juvenis*. The difference between these specimens and *N. liratus*, however, seems to be specific rather than varietal.

215. Nautilus, fragments.

A number of fragments of *Nautilus* found in various parts of the section were too imperfect for specific identification.

Suborder CYRTOCHOANITES Hyatt.

Family PHRAGMOCERATIDÆ.

Genus GOMPHOCERAS Sowerby.

216. Gomphoceras, sp.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 318.

A single crushed specimen of this genus was found in Zone C. The markings were obliterated to such an extent that it was impossible to make a specific identification.

Order AMMONOIDEA.

Suborder EURYCAMPYLI Hyatt.

Family GLYPHIOCERATIDÆ.

Genus GONIATITES de Haan.

217. Goniatites discoideus Hall.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 441, pls. 71, 74.

Casts of the test showing the fine, closely arranged striæ, "raised at intervals in fascicles," were commoner than those showing the septa. This species was fairly common in Zone T. In Zone I a number of imperfect specimens which were either of this species or of *G. uniangularis* were quite frequently found. Elsewhere in the section they are very rare.

218. Goniatites uniangularis Conrad.

Pal. N. Y., vol. 5, pt. 2, 1879, p. 444, pls. 71, 74.

This species was very rare, but several well-preserved specimens were found. One almost perfect small specimen from the lower shales of Zone C measured 15 mm. in diameter in the widest part. A large specimen measured 45 mm. in diameter.

Subkingdom ARTHROPODA.

Class CRUSTACEA.

Subclass TRILOBITA.

Order OPISTHOPARIA Beecher.

Family PRÖETIDÆ Barrande.

Genus PRÖETUS Steininger.

219. Pröetus rowi Green.

Pal. N. Y., vol. 7, 1888, p. 119, pls. 21 and 23.

A portion of the cephalon with a crushed glabella and a perfect genal spine was referred, with some doubt, to this species.

220. Prōetus microgemma Hall.

Pal. N. Y., vol. 7, 1888, p. 109, pl. 22.

An imperfect pygidium was referred with considerable certainty to this species.

221. Prōetus macrocephalus Hall.

Pal. N. Y., vol. 7, 1888, p. 116, pls. 21 and 23.

A pygidium and thorax were found in Zone Y and a glabella in the Encrinal bed. The surface markings are quite plain.

Genus HOMALONOTUS Köenig.

222. Homalonotus dekayi Green.

Pal. N. Y., vol. 7, 1888, p. 7, pls. 2, 3, 4, 5.

This is quite a common fossil in the upper portion of the Encrinal band. A fragment of a pygidium was found in Zone Y and a portion of a cephalon in Zone D. At Eighteenmile Creek it is reported from the lower portion of the Lower Hamilton. In Kashong Creek it occurs rarely in the Upper Hamilton.

Order PROPARIA Beecher.

Family PHACOPIDÆ Salter.

Genus PHACOPS Emmrich.

223. Phacops rana Green.

Pal. N. Y., vol. 7, 1888, p. 19, pls. 7, 8, 8A.

This is a common and sometimes an abundant species in this section. Above the Encrinal it occurs in almost every zone. Occasionally a complete specimen was found. It is usually associated with *D. boothi* and *A. umbonata*.

224. Phacops cristata var. pipa Hall.

Pal. N. Y., vol. 7, 1888, p. 18, pl. 8.

A specimen of this variety was found in Zone A.

Genus DALMANITES Emmrich.

225. Dalmanites boothi Green.

Pal. N. Y., vol. 7, 1888, p. 42, pls. 16, 16A.

This species was found in the lowest portion of Zone C. It is common throughout the section from Zone D to the Tully, especially above the Encrinal.

At Eighteenmile Creek it is commonest below the Encrinal, while at Cayuga Lake the opposite is true.

226. Dalmanites boothi var. calliteles Green.

Pal. N. Y., vol. 7, 1888, p. 45, pls. 16, 16A.

A few specimens of this variety were found in the upper portion of the Upper Hamilton.

Subclass EUCRUSTACEA Kingsley.

Superorder MALACOSTRACA Latreille.

Order PHYLLOCARIDA Packard.

Suborder Ceratiocarina Clarke.

Family ECHINOCARIDÆ Clarke.

Genus ECHINOCARIS Whitfield.

227. Echinocaris punctata Hall.

Pal. N. Y., vol. 7, 1888, p. 166, pls. 27, 28, 29.

Five specimens of this species were found in the Cayuga Lake section, one in the Upper and four in the Lower Hamilton above Zone D.

Genus TROPIDOCARIS Beecher.

228. Tropidocaris hamiltoniæ Hall.

Pal. N. Y., vol. 7, 1888, pl. 30.

A right valve of this species was found in Zone O. It measured 10 mm. in length.

Suborder RHINOCARINA Clarke.

Family RHINOCARDIDÆ Clarke.

Genus RHINOCARIS Clarke.

229. Rhinocaris sp.

Pal. N. Y., vol. 7, 1888, p. lviii, pl. 31.

Two specimens of this genus, one with both valves, the other with one valve of the carapace were found in the shale of Zone C along Dean Creek. The preservation was too imperfect to permit of specific identification.

Genus MESOTHYRA Hall and Clarke.

230. Mesothyra oceani Hall.

Pal. N. Y., vol. 7, 1888, p. 187, pls. 33 and 34.

Two specimens of this genus were referred doubtfully to this species. Neither specimen is perfect enough to warrant a specific identification. The length of the carapace is 20 mm. and 45 mm., respectively.

231. Superorder OSTRACODA Latreille.

The various species and genera of this superorder seem to have been adapted to the same conditions of environment during the Hamilton stage. They are common in the fine shale of Zones B, C, and E.

PLANTÆ.

Genus LEPIDODENDRON Sternberg.

232. Lepidodendron gaspianum Dawson.

Quar. Jour. Geol. Soc., 1859, vol. 15, p. 484.

A specimen of this plant with distinct imprints of the leaves was found in Zone C.

Thanks is due Professor Penhallow for the identification.

233. Plant fragments.

Plants, usually in a poor state of preservation, were scattered throughout the section. Within a foot or two of the Tully limestone plant fragments were especially well preserved and abundant.

Genus TAONURUS.

234. Taonurus sp.? Fischer-Ooster.

This fucoid was very abundant in the upper portions of the Upper and Lower Hamilton.

CHAPTER V.

COMPARISON OF THE CAYUGA LAKE SECTION WITH OTHER SECTIONS OF THE HAMILTON FORMATION.

BASAL LIMESTONE.

The Basal limestones of Ontario County are described by J. M. Clarke, as follows:[a]

Within 10 feet of the top of the Marcellus shales, where the rocks still retain their characteristic color and diagnostic fossils, appear *Spirifer mucronatus* and *Ambocœlia umbonata* of the Hamilton fauna, such Hamilton species increasing in number and the rocks becoming less and less bituminous until at the top of 10 feet the bituminous character has disappeared and with it the Marcellus fauna. Overlying is a series of strata of limestone more or less impure and persisting throughout the county east and west.

Farther east the same strata become more shaly and lose many of the fossils of the richer western outcrop. Dr. D. F. Lincoln[b] accepted the term "Basal Hamilton," proposed by J. M. Clarke, and the description of Hall in the report of the Fourth District[c]—"a compact calcareous blue shale passing into an impure limestone." He says that it retains this character (of a coral reef) to some extent in Seneca County, displaying scattered fragments of *Heliophyllum*, *Favosites*, and other large corals which do not belong elsewhere in the region.

From the description given above and from its position in the section (see map Pl. I) it seems certain that the compact calcareous shales of Zone D should be correlated with the Basal Hamilton of Ontario and Seneca counties.[d] There is, however, considerable difference in the faunules. Although the corals are very much rarer in Zone D at Cayuga Lake compared with that stratum in the west, yet *Heliophyllum* is common only in this stratum in the Cayuga Lake section. This zone is characterized in Ontario County by a great abundance of Crustacea. The development of Crustacea in Zone D is by no means remarkable, only three species of trilobites being found, none of which were abundant.

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[a] Report State Geol., New York, 1885.

[b] Ibid., 1894.

[c] 1843.

[d] Since the above was written the author revisited the localities on Seneca Lake. There is no doubt as to the correctness of the correlation.

A comparison of the Basal Hamilton of Ontario County, Seneca County, and Zone D of Cayuga Lake shows a decrease in the amount of calcareous matter and in corals from west to east. It is probable that the region along Cayuga Lake was the edge of the reef, if such it can be called, and that the conditions were such that most of the species of corals and Crustacea which flourished so well in the west were represented in the Cayuga Lake region by an abundant brachipod and pelecyopod fauna, with here and there a large *Heliophyllum halli* and a colony of *Syringopora*.

This impure limestone layer, the Basal Hamilton, is, next to the Encrinal beds, the most persistent stratum in the New York Hamilton, extending as it does for more than 40 miles from east to west.

I. P. Bishop, in the Geology of Erie County, mentions[a] a calcareous stratum in that county which he correlated provisionally with the Basal limestone of Clarke. The evidence for this correlation is so unsatisfactory that it must be disregarded.

ENCRINAL BEDS.

In comparing the faunules of the Encrinal beds with that of Eighteenmile Creek, it was found that of 8 lamellibranchs of the Eighteenmile Creek Encrinal 4 are found in the Encrinal of the Cayuga Lake section, 2 are extremely rare, and 2 have been found nowhere in this section. Of the 35 brachiopods, 13 were not found in the Encrinal of Cayuga Lake. But of that number 4 have not been found elsewhere in the section and 4 are extremely rare. *Vitulina pustulosa*, *Centronella impressa*, *Meristella haskinsi*, and *Heliophyllum confluens* are restricted to the Encrinal at Eighteenmile Creek. With the exception of *V. pustulosa* and *M. haskinsi*, which was found in the Encrinal and Zone D, these species are restricted to the Encrinal at Cayuga Lake. Grabau[b] finds the Encrinal at Eighteenmile Creek to be the equivalent of that at Livonia. The comparison of the fossils from that stratum in the two places brings out the fact that only one species given in the Livonia list is wanting in the limestone at Eighteenmile Creek. James Hall[c] considered the Encrinal as a "persistent mass holding only one position in the group and continuous as far as Lake Erie. It is a convenient point of reference." It is 1½ feet thick at Lake Erie, 2 feet at Livonia, 3 feet in Yates County, and 1½ feet in Cayuga County.

Prof. C. S. Prosser,[d] in discussing Professor White's correlation of a zone in eastern Pennsylvania which is as rich in corals and crinoids as the Tully, shows by the fossil content that the Genesee shales of White are Hamilton shales. The so-called Tully does not contain any

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[a] Report State Geol. New York, 1895.
[b] Report State Geol. New York, 1898.
[c] Report Fourth District New York, 1843.
[d] Bull. U. S. Geol. Survey No. 120, 1894, p. 74.

characteristic Tully fossils, but contains only Hamilton species. He says:

If a correlation of this zone with one of central and western New York were attempted, I would suggest the Encrinal limestone separating the fossiliferous argillaceous Ludlowville and Moscow shales. As the Pennsylvania horizon may be represented by any one of the several coral horizons in the Hamilton of New York or by an entirely different one, such a correlation of this zone is very hazardous without careful comparison of the species and stratigraphy.

On the east shore of Skaneateles Lake, 2½ miles from the head of the lake, is a bed of cyathophylloid and other genera of corals 5 feet thick, which are described by Luther.[a] Luther concludes, from its position and from the fact that it "abounds in cyathophylloid corals which characterize the Encrinal of the western counties," that it is probably the eastern extension of the Encrinal band. Since in Ontario, Seneca, and Cayuga counties the most abundant coral faunas are in the Basal Hamilton, either this coral reef at Skaneateles Lake is (1) a continuation of the stratum called the "Basal Hamiton," which is several hundred feet above the Marcellus shales in the Cayuga Lake section, or (2) the Encrinal, or (3) the union of (1) and (2), or (4) a separate stratum. With the data now at hand Luther's supposition is as probable as any other.

Since the Encrinal is found in a number of localities between Lake Cayuga and Lake Erie, of the same lithological character, in relatively the same position in the shale, with a fauna which changes little in a distance of 125 miles, it should be considered as a continuous stratum. East of Cayuga Lake the correlation of the coral zones is yet to be worked out. However, conditions of sedimentation such as would produce a limestone stratum anywhere in the Middle Hamilton would be adapted to and contain what might be called a limestone fauna which would not differ materially from the fauna of the Encrinal; and whether this stratum were continuous or not, the same association of fossil would probably exist.

GASTEROPODA.

Gasteropoda predominate both in specific and in individual development in the lower shales of Ontario County. This is also the condition at Eighteenmile Creek, where only one gasteropod, *Platyostoma lineata*, is found above the Encrinal, and that but rarely in one layer. In the Cayuga Lake section Gasteropoda are not common in any portion of the section, but are about as frequently met with above as below the Encrinal. They occur, however, rather more frequently, in proportion to the Pelecypoda and Brachiopoda, in the fine shales of Zone C.

[a] Report State Geol. New York, 1895.

USE OF TERMS "UPPER" AND "LOWER" HAMILTON FAUNA.

The data at hand—the faunules of the Cayuga Lake, Eighteenmile Creek, and Livonia sections—are sufficient to warrant some definite statement as to the propriety of the terms "an Upper Hamilton fauna" or "a Lower Hamilton fauna," used by some writers as signifying an ability to distinguish between them.

A comparison of the Cayuga Lake section with that of Eighteenmile Creek shows that the relative abundance of species and individuals in the Upper and Lower Hamilton of the two sections is reversed. At Cayuga Lake the number of species and individuals is greater above than below the Encrinal beds, while the opposite is decidedly true of the Eighteenmile Creek section.

Spirifer granulosus is a rather common fossil above and below the Encrinal at Cayuga Lake, but is restricted to the Lower Hamilton and the Encrinal at Eighteenmile Creek and to the Upper Hamilton at Livonia. *Reticularia fimbriata*, *Tropidoleptus carinatus*, and the lingulas are distributed in the three sections in the same manner as *Spirifer granulosus*.

Stropheodonta concava and *S. junia* are in the Lower Hamilton at Eighteenmile Creek, but are restricted to the Upper Hamilton at Cayuga Lake and Livonia.

Only two species of Brachiopoda have been found, which are restricted to the Upper Hamilton of the three sections, exclusive of the Encrinal — *Ambocœlia præumbona* and *Spirifer marcyi*. But it would not be remarkable if even these were found lower. Since these species have not been reported east of Cayuga Lake, they must of necessity have little use in stratigraphy. *Ambocœlia præumbona* has not been reported outside of New York State, and it may have originated in western New York after the Encrinal band was deposited.

Leiorhynchus limitare, *Spirifer macrus*, *Anoplotheca camilla*, and *Strophalosia truncata* are species which have not been reported above the Encrinal beds. The first is a typical Marcellus fossil (reported by Clarke[a] in a "recurrent fauna" above the "Basal limestone" in Ontario County); the second and third are typical Onondaga (Corniferous) species which have never been found above the Marcellus; only the fourth, *Strophalosia truncata*, is a species often found in the Hamilton. A comparison of the corals, pelecypods, and gasteropods brings the same results.

From the above it will be seen that the burden of evidence at present is against the supposition that it is possible, without the aid of stratigraphy, to distinguish between the Upper and Lower Hamilton fauna. However, the presence of *Spirifer marcyi* and *Ambocœlia præumbona* and the absence of *Strophalosia truncata* in a fauna would be presumptive evidence of the Upper Hamilton.

[a] Rept. State Geol. New York, 1886.

EXPLANATION OF DIAGRAM, FIG. 3.

The data from which this diagram was constructed were obtained from the New York Geological Reports, commencing with vol. 4, 1867, Palæontology of New York, together with the Peabody Museum collections from Onondaga, Cayuga, Seneca, Genesee, and Erie counties used in the preparation of this paper. The distances are only approximate, some noted collecting locality being usually taken as a center.

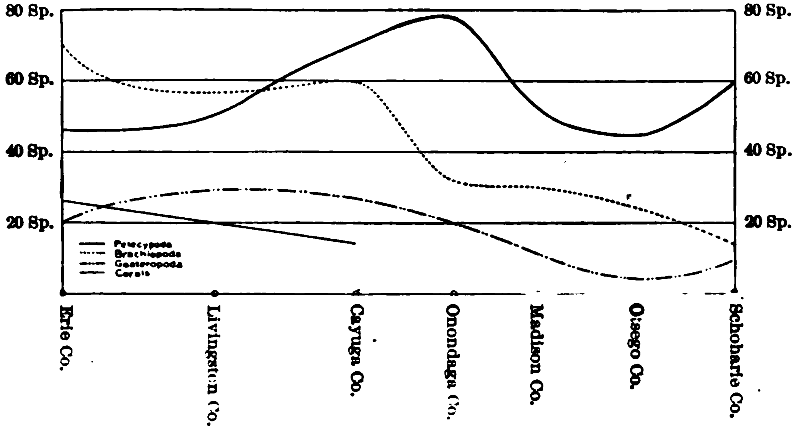

FIG. 3.—Diagram showing the distribution of fossils of the Hamilton stage throughout New York State.

The curves from Onondaga County west are probably more nearly correct than those east, because of the exceptionally careful collections from Pompey, Cayuga Lake, Livonia, and Eighteenmile Creek. The faunal lists of Prof. C. S. Prosser[a] make the collections from the extreme eastern portion of the State fairly full.

As is readily seen, the center of abundance of Pelecypoda is in Onondaga County. From that point the decrease to the west is rapid. The decrease in the number of species of Pelecypoda in the arenaceous shales east of Onondaga County would probably be less than represented were fuller collections to be had. That the conditions in eastern New York were much less favorable to the development of brachiopods than of pelecypods is shown by the fact that the relative abundance of brachiopods to pelecypods in Schoharie County is 13:60, while at Lake Erie the ratio is 70:40.

The increasing abundance of species of brachiopods from east to west is very striking and uniform. The line showing the abundance of Gasteropoda varies less from east to west than the other classes. The data concerning the corals show a uniform increase between Cayuga and Erie counties.

[a] Fifteenth Ann. Rept. State Geol. New York, 1895.

Two facts should be borne in mind in the consideration of the relative abundance of fossils when studied geographically, (1) the excellent opportunities for collecting in certain localities, as central and western New York, and the greater difficulty in others, as the eastern counties of New York, and (2) the fact that often in a formation the same time elapsed during the deposition of a few feet of sediment in one place that it took for the deposition of many times that thickness in another locality in the formation. The time required for the deposition of the 67 feet of sediment at Eighteenmile Creek, the 517 feet at Livonia, the 1,100 feet at Cayuga Lake, and the great thickness of the eastern shales was the same. At any one time there may not have been a greater number of living shells in Erie County than in the central or eastern part of the State; the conditions were, however, more favorable for the development of brachiopods and corals than for pelecypods.

The change from east to west, not only in the relative number of species but in the species themselves, is spoken of by Hall[a] as follows: "So great is this change that if a collection of fossils from the Hamilton formation in the counties of Albany and Schoharie be compared with a collection from the same group in Genesee and Erie counties the number of species common to both would be less than has been sometimes indicated as passing from one geological formation to another."

[a] Preface to Pal. New York, vol. 4, 1867.

CHAPTER VI.

CONCLUSIONS.

In this investigation the following conclusions have been reached:

(1) There are a number of fossil faunules in the Hamilton formation which can be quite accurately defined. A glance at the diagrams Pl. V, *A* and *B*, and the table (Appendix) shows the distinctness with which many of these faunules are marked off. On the present sea bottom it is possible, given the conditions of bottom, depth, temperature, etc., in any region, to state with considerable certainty the composition of the faunule. The boundary line between modern faunules is sometimes distinct, but often there is such a mixture of the two faunules at the boundary that it is impossible to state where the line should be drawn. In the vertical distribution of fossil faunules the same difficulty is encountered. Shales containing a mixture of faunules are not uncommon, but where uniform conditions prevailed for a considerable length of time a definite group of species occurs. Occasionally the change was sudden, and the faunules are separated by a distinct line. Zone D is an excellent example of such a case; the shales above and below are almost barren of fossils, while Zone D is very fossiliferous. Occasionally a thin layer of fine shale is seen in the midst of a fossiliferous zone, or a thin layer rich in fossils in a barren zone.

(2) The difference between the composition of different faunules of the Hamilton formation is often more marked than between faunules of the same facies belonging to different formations. A study of living faunules leads one to expect such a condition, since in a short distance bathymetrically and geographically there is often a complete change in species.

(3) Migration of the organisms which lived during the Hamilton stage was undoubtedly accomplished in the same way as at present.[a] Such animals as Crustacea and *Orthoceratites* had considerable power of movement in the adult condition, but the common fossil animals, such as the brachiopods and pelecypods, were practically stationary when mature. The only means of migration for such classes was during the free swimming stage. During this stage they were carried about by currents and to some extent moved by their own activity.

[a] See Parker and Haswell, Text-Book of Zoology, and other Zoologies. Marine Bionomy Graban

Zoologists cite many cases of the sudden appearance of species previously unknown to certain localities which were carried there during the free swimming stage by unusual conditions. These species often live but one year, and may not be seen again for years. Drifting timber and other means enable old and young of certain species to be carried long distances. The migration of the species making up the bulk of the Hamilton faunules undoubtedly took place, for the most part, during the free swimming stage.

(4) The repetition of faunas such as are found in a section like that of Cayuga Lake shows that there was an oscillation of similar conditions. It is probable that had the conditions remained uniform during the whole of the stage only one of these faunas would have occurred. The *Leiorhynchus* zone is several hundred feet thick in this region. There is no objection to the supposition that such a faunule would have lived on throughout the stage had the conditions remained as they were during the deposition of that zone.

(5) An "accidental" faunule is one which has been produced in a long period of time in a region where sedimentation has been very slight, but in which the conditions changed for short periods sufficiently to introduce a few species. In the aggregate the number of species of such a faunule may be great. A faunule of this character is very confusing, composed, as it is, of species from perhaps several faunules. It was not unusual for a thousand or more feet of sediment to be deposited in one region, while in another, during the same period of time, only a few feet were laid down. It is consequently unsafe to say, because fossils are abundant in a few inches of shale, that the conditions were necessarily exceptionally favorable for the development of that faunule. It is not impossible that hundreds or even thousands of years may have elapsed during the deposition of such a zone. The comparison of the thickness of the Hamilton formation at Cayuga Lake with that at Eighteenmile Creek showed that while 1,100 feet of shales were deposited in the Cayuga Lake region only 67 feet were deposited at Eighteenmile Creek. On the other hand, that great length of time and little sedimentation are not necessary for the formation of all fossiliferous zones is evident from the peculiar and characteristic faunules of these zones and the position of the fossils in the shale and limestone.

(6) In a section such as that of the Hamilton formation at Cayuga Lake, which represents in its formation between 1,846,150 and 26,153,840 years,[a] if the statement "natura non saltum facet" is granted, one should, with some confidence, expect to find many—at least some—evidences of evolution. A careful examination of the fossils of all the zones, from the lowest to the highest, failed to reveal any evolutional changes, with the possible exception of *Ambocœlia præumbona*.

[a] The first estimate is from Dana; the second is the maximum of Geikie. The Meso-Devonian was estimated as one-third the Devonian.

The species are as distinct or as variable in one portion of the section as in another. Species varied in shape, in size, and in surface markings, but these changes were not progressive. The conclusion must be that, so long as the conditions of sedimentation remain as uniform as they were in the section under consideration, the evolution of brachiopods, gastropods, and pelecypods either does not take place at all or takes place very seldom, and that it makes little difference how much time elapses so long as the conditions of environment remain unchanged.

(7) An analysis of the Hamilton faunas shows conclusively that there is little basis for the terms "an upper" and "a lower Hamiltonian fauna" unless these terms are used to signify that it is possible in isolated sections to state, from the composition of the fauna, whether the rock is above or below the Encrinal bed.

[illegible]
from last, read whom.

CHAPTER VII.

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APPENDIX.—*Table showing vertical distribution of faunal zones, with their contained faunules, in the Hamilton formation of Cayuga Lake, New York.*

[A = abundant. C = common. Cr = fairly common. r = rare. R = very rare.]

	Marcellus.		Lower Hamilton.									Encrinal bed.	Upper Hamilton.												
	Hamilton-Onondaga (Corniferous) zone.	First Leiorhynchus zone.	Second Leiorhynchus zone.	First Terebratula zone. (See text.)	Third Leiorhynchus zone.	Michelinia zone.	Chonetes vicinus zone.	(Transition zone.)	First Cypricardella-Athyris zone.	Tellinopsis zone.	Second Cypricardella-Athyris zone.	Second Terebratula zone.	Orthonota zone.	(Transition zone.)	Chonetes zone.	First Ambocœlia zone.	Chonetes lepidus zone.	Second Ambocœlia zone.	Stropheodonta-Coralline zone.	Modiella pygmæa zone.	Ambocœlia præumbona zone.	Orbiculoidea zone.	(Transition zone.)	Spirifer-Atrypa zone.	Cystodictya zone.
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
ANTHOZOA-ACTINOZOA.																									
1. Streptelasma rectum				r		R			r										A	R		Cr	Cr	C	R
2. Zaphrentis simplex																									R
3. Amplexus sp. undet																				Cr			C	Cr	R
4. Heliophyllum halli				Cr																				R?	
5. H. confluens												R													
6. Diphyphyllum archiaci																									R
7. Favosites argus																									R
8. F. sp. (undet.)			R						R			r													R
9. Michelinia stylopora						Cr			R										R	R					
10. Trachypora ornata												r													R
11. Aulopora serpens			R						R?																R
12. Ceratopora dichotoma						r			R						R										
13. Syringopora sp				r																					
14. Chætetes fructicosa										R															R

APPENDIX.—*Table showing vertical distribution of faunal zones, with their contained faunules, in the Hamilton formation of Cayuga Lake, New York*—Continued.

	Marcellus.		Lower Hamilton.									Encrinal bed.	Upper Hamilton.												
	Hamilton-Onondaga (Corniferous) zone.	First Leiorhynchus zone.	Second Leiorhynchus zone.	First Terebratula zone. (See text.)	Third Leiorhynchus zone.	Michelinia zone.	Chonetes vicinus zone.	(Transition zone.)	First Cypricardella-Athyris zone.	Tellinopsis zone.	Second Cypricardella-Athyris zone.	Second Terebratula zone.	Orthonota zone.	(Transition zone.)	Chonetes zone.	First Amboccelia zone.	Chonetes lepidus zone.	Second Amboccelia zone.	Stropheodonta-Coralline zone.	Modiella pygmæa zone.	Amboccelia præumbona zone.	Orbiculoidea zone.	(Transition zone.)	Spirifer-Atrypa zone.	Cystodictya zone.
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
CRINOIDEA.																									
15. Granatocrinus leda												R													
16. Ancyrocrinus bulbosus												R													
17. Dichocrinus									R																
18. Crinoid stems and plates			RR	C	R	C			r	r		A	C	C	R	R		R	A	Cr			r	Cr	C
VERMES.																									
19. Spirorbis angulatus		R																							
BRYOZOA.																									
20. Hederella canadensis																									R
21. Reptaria stolonifera		R																							R
22. Tæniopora exigua																									Cr
23. Cystodictya incisurata																			Cr					C	A
24. Polypora multiplex																			r						
25. Bryozoa, undet				Cr	R	R			R	r	r	C	Cr	C	R			R	C	R				C	AA
BRACHIOPODA.																									
26. Lingula delia						R?		R	R?					R?	R					R		Cr		R	R
27. L. densa															R?					R					
28. L. ligea									R															R	R
29. Dignomia alveata													R												

30. Camarotœchia congregata				R					R					r											R
31. C. dotis												r?													
32. C. horsfordi												R													R
33. C. prolifica						r ?						r?							r					R?	R
34. C. sappho				R			R					R												R	R
35. Hypothyris cuboides																									r
36. Leiorhynchus laura	Cr?		C	R	C	R			R							R				R	R	A	CA	C	
37. L. limitare		C																							
38. Centronella impressa												C													
39. Cryptonella planirostris				r																					
40. C. rectirostris				Cr																					
41. Eunella lincklæni				Cr								Cr												r	Cr
42. Tropidoleptus carinatus	R		R	Cr	r	C	Cr	C	CA	R	Cr	C	CA	CA	C	r		r	R	Cr	R			R	CA
43. Atrypa reticularis				R					R		Cr								C	R		r	r	A	Cr
44. Cyrtina hamiltonensis				Cr															R	R					R
45. Spirifer audaculus				Cr					R		Cr	R		Cr	R				r	Cr		R	CA	A	CA
46. S. audaculus macronotus				r					r		r	R							Cr	Cr				r	
47. S. divaricatus				R								r													
48. S. granulosus				R		R			Cr		Cr	Cr			r				r	Cr				C	R
49. S. marcyi																								C	Cr
50. S. pennatus			R	r		Cr	C	C	A	Cr	C	C	r	A	C			Cr	r	Cr	C	R	Cr	Cr	C
51. S. tullius									R			Cr			R					r	Cr	Cr			
52. S. macrus	C																								
53. Delthyris consobrina				R					R						R			Cr	Cr	R				R	
54. D. sculptilis				r																					
55. Martinia subumbona																				R					
56. Ambocœlia præumbona																				R	C	Cr			
57. A. umbonata	Cr	Cr	Cr	C	Cr	r			R	C	R		Cr	R	Cr	A	C	AA	R	C	C	Cr		R	R
58. Reticularia fimbriata				Cr					r			R		C					r			R	R	r	Cr
59. Nucleospira concinna				r								Cr							Cr						R
60. Anoplotheca camilla	Cr																								
61. Vitulina pustulosa				Cr								Cr													
62. Athyris spiriferoides	CA			Cr		R			CA	R	CA	r		r	C	Cr		C	Cr	Cr		r	A	A	Cr
63. Meristella haskinsi				R								R													
64. Orbiculoidea doria			R			R														R					

APPENDIX.—*Table showing vertical distribution of faunal zones, with their contained faunules, in the Hamilton formation of Cayuga Lake, New York*—Continued.

	Marcellus.	Lower Hamilton.									Encrinal bed.	Upper Hamilton.													
	Hamilton-Onondaga (Corniferous) zone.	First Leiorhynchus zone.	Second Leiorhynchus zone.	First Terebratula zone. (See text.)	Third Leiorhynchus zone.	Michelinia zone.	Chonetes vicinus zone.	(Transition zone.)	First Cypricardella-Athyris zone.	Tellinopsis zone.	Second Cypricardella-Athyris zone.	Second Terebratula zone.	Orthonota zone.	(Transition zone.)	Chonetes zone.	First Ambocœlia zone.	Chonetes lepidus zone.	Second Ambocœlia zone.	Stropheodonta-Coralline zone.	Modiella pygmæa zone.	Ambocœlia præumbona zone.	Orbiculoidea zone.	(Transition zone.)	Spirifer-Atrypa zone.	Cystodictya zone.
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
BRACHIOPODA—continued.																									
65. Orbiculoidea humilis										R															
66. O. lodiensis																				R					
67. O. lodiensis media			R	R						R?					R	Cr		R		R		A	R		
68. Craniella hamiltoniæ				R								R							R	R			R	R	Cr
69. Pholidops hamiltoniæ									Cr						Cr	C	R	CA	r	C	C		CA	R	
70. P. oblata												R													
71. Stropheodonta concava																			Cr					Cr	R
72. S. demissa									R																
73. S. inæquistriata				R					r			Cr							C					r	C
74. S. junia														r								R	r	Cr	Cr
75. S. perplana	R			C		R		R	Cr		Cr	C		R	R		R	r	Cr			r	C	Cr	r
76. S. perplana var																							R		
77. Pholidostrophia iowaensis									C	R				R											R
78. Orthothetes chemungensis arctistriatus	R			Cr		R			Cr			Cr	R	R	R				R	R				R	R
79. O. chemungensis perversus				Cr							R														
80. O. chemungensis var	Cr																								
81. Chonetes coronatus	R			Cr				C	r	R	Cr	Cr		Cr	Cr				C	r				R	R

82. C. lepidus			R	R	r						r				r	r	A	Cr	Cr	r	r	R	R	Cr	r
83. C. lineatus	C																								
84. C. mucronatus	CA	C	r	CA							r	r	r		A	C	R	C	r	C	r	R	A	Cr	r
85. C. scitulus		r	R							A		r			A		r	r	Cr	Cr		r		R	R
86. C. setigerus																				R					
87. C. vicinus				R		r	A	A	CA		Cr														
87a C. sp																									
88. Productella spinulicosta		R	R	Cr		Cr			r	r	r	R			R				R	R			R	r	r
89. P. navicella			R																						
90. Strophalosia truncata		C	r		R	r				R										R?					
91. Rhipidomella vanuxemi									R?		R	C			R			Cr	CA	C	R	R	A	Cr	Cr
92. R. cyclas																				R					
93. R. penelope																									R
93a. Pentamerella pavilionensis				R																					
PELECYPODA.																									
94. Phthonia nodicostata													Cr												
95. P. cylindrica																			R						R
96. P. sectifrons																									R
97. Orthonota carinata									R		R								R	R					
98. O. undulata										Cr	R		C											R	
99. O. parvula				R				Cr	R						R	R			R	r	R		R	R	
100. Prothyris lanceolata											r		Cr								R			R	R
101. P. truncata																								r	R
102. Grammysia constricta							R	r		R			R		R					R				R	
103. G. cuneata				Cr?					R	Cr					r			R		R					
104. G. arcuata				Cr		R	r	R	R	R	Cr		r		R					R					R
105. G. bisulcata							r																		
106. Elymella fabalis																									R
107. E. nuculoides																								R	
108. Glossites subtenuis																								R	
109. Tellinopsis subemarginata			R	Cr		r	C		R	CA	r		Cr			R		R	R	r	R	R	R	Cr	
110. Panenka lincklæni																				R?					
111. P. potens			R?																	R?					
112. P. sp																								R	

APPENDIX.—*Table showing vertical distribution of faunal zones, with their contained faunules, in the Hamilton formation of Cayuga Lake, New York*—Continued.

	Mar-cellus.		Lower Hamilton.									Encrinal bed.	Upper Hamilton.												
	Hamilton-Onondaga (Corniferous) zone.	First Leiorhynchus zone.	Second Leiorhynchus zone.	First Terebratula zone. (See text.)	Third Leoirhynchus zone.	Michelinia zone.	Chonetes vicinus zone.	(Transition zone.)	First Cypricardella-Athyris zone.	Tellinopsis zone.	Second Cypricardella-Athyris zone.	Second Terebratula zone.	Orthonota zone.	(Transition zone.)	Chonetes zone.	First Ambocœlia zone.	Chonetes lepidus zone.	Second Ambocœlia zone.	Strophedonta-Coralline zone.	Modiella pygmæa zone.	Ambocœlia præumbona zone.	Orbiculoidea zone.	(Transition zone.)	Spirifer-Atrypa zone.	Cystodictya zone.
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
PELECYPODA—continued.																									
113. Glyptocardia speciosa			R		Cr	r			R									R		R		R			
114. Nuculites triqueter		C	Cr		R	Cr		R	Cr	C	Cr				r			R	r	Cr	R	r	Cr	r	R
115. N. oblongatus			R	R	R	R	R		R	C	R		r		R				r	Cr		r	C	Cr	R
116. Nucula varicosa					R	R		R			R									r	r	R	R		
117. N. randalli									R?																
118. N. lirata			R			R			R	r					R				r	Cr	R		R	r	
119. N. bellistriata							R	R	r	C	Cr				R?					Cr	Cr			R	
120. N. corbuliformis		r	R	R	C	Cr		Cr		r	Cr			R	Cr	r	R	Cr	R	C		Cr	R	R	R
121. Leda rostellata									R	r	R								Cr	R	R			R	
122. L. brevirostris																									R
123. Palæoneilo constricta			R	Cr		R	Cr	C	Cr	R	Cr		Cr	r	C	r	Cr	C	r	C	C	R	C	C	r
124. P. emarginata									Cr			R		R						Cr	r	r	Cr	r	R
125. P. plana																		R	R	Cr			C	R	
126. P. maxima																									R
127. P. muta																R?		R	R	r				r	
128. P. fecunda									R									R		R				R	
129. P. tenuistriata																						R	Cr	r	

130. Parallelodon hamiltoniæ			Cr		R		R	r		R	R			R			C	r	r			Cr	Cr	R
131. Sphenotus arcæformis										R														
132. S. cuneatus						r	R																	
133. S. solenoides			R								R													
134. Pterinea flabella			R		r		R?	Cr																
135. Lunulicardium fragile	R	Cr	r	Cr	R	r										R			R				R	
136. L. curtum	R	R	R	R																				
137. L. ornatum		R																						
138. Plethomytilus oviformis			R		R																		R	R
139. Mytilarca gibbosa													R?											R?
140. Spathella typica																							R	
141. Conocardium normale										R														
142. Actinopteria boydi			Cr					R											R				R	r
143. A. decussata											R								R				R	
144. A. subdecussata																			R					
145. Leiopteria greeni											R													
146. L. lævis	C	R	r	R	Cr	R		r											Cr	Cr?	r		r	
147. L. rafinesquii			R						r?															
148. L. gabbi		R																	R?					
149. L. sayi							R	R?						R			R?		Cr					
150. L. conradi			R																R					
151. L. dekayi																			R					
152. Modiella pygmæa		R	r	C	Cr			r	Cr					r	R	R	r	R	CA	r	Cr	C	Cr	
153. Schizodus appressus			R					R			r						R			R?			R	
154. S. contractus			R																					R
155. Aviculopecten princeps			Cr	R	R			Cr	R		R	R	r?										Cr	Cr
156. A. fasciculatus			R?																					
157. A. scabridus					R																			
158. Pterineopecten undosus								R		R									R?	R	R		R	R
159. P. vertumnus								R	R?															R
160. P. intermedius			r		R				R					R			R	R	R					R
161. P. hermes														R				r				R		r
162. Lyriopecten orbiculatus			R																					
163. Modiomorpha subalata			r		Cr				Cr										r		R		R	
164. M. concentrica			R				C	Cr		R	R			Cr			r	Cr	r			C	Cr	R

APPENDIX.—*Table showing vertical distribution of faunal zones, with their contained faunules, in the Hamilton formation of Cayuga Lake, New York*—Continued.

	Marcellus.		Lower Hamilton.									Encrinal bed.	Upper Hamilton.												
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	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
PELECYPODA—continued.																									
165. Modiomorpha mytiloides				r		r		R	r			R			Cr								r	r	
166. M. alta																								R	
167. Goniophora hamiltonensis				r					R?		R		R					R	R	R					R
168. G. truncata																			R					R	
169. G. rugosa								R	R										R?	R				R	
170. G. glaucus																								R?	
171. Pholadella radiata				R		r		Cr	r	Cr				R	C		R	R		r		R			
172. P. parallela																				R					
173. Cimitaria corrugata									R															R	
174. C. elongata												R													
175. Cypricardella bellistriata				r		Cr	Cr	CA	CA		Cr	r			R					r			C	C	Cr
176. Cypricardinia indenta				Cr					R										R	R			r	C	R
177. Paracyclas tenuis				R				R	r	R	Cr				R	R	r	Cr		R	R		Cr	R	
178. P. lirata																				R					
GASTEROPODA.																									
179. Pleurotomaria itys			r						R	R					R					r			r	R	R
180. P. capillaria				R		R												R		r	r	R			

181. P trilix														R							R			R	R
182. P. sulcomarginata		Cr																		R			R		
183. P rotalia			R																	R?					
184. P. rugulata		Cr	r		Cr	r			R																
185. Bellerophon patulus			R	R		R				R	R			Cr											r
186. B. leda			Cr	R	r	R		R	R	C			r	Cr	R					R			R	r	
187. B. lyra															R										
188. B crenistria			R						R			R	R							R				R	
189. Cyrtolites mitella									r	Cr										R					
190. Euomphalus sp															R										
191. Platyceras conicum												R													
192. P. erectum					R							R		Cr					R	R				R	r
193. P. bucculentum																			R					R	
194. P. carinatum																							R	R	
195. Platyostoma lineata														R					R	R					Cr
196. P. varians										R															
197. Loxonema hamiltoniæ	R?	R	r			R			R			R	Cr		R					R				r	
198. L. delphicola				r?					r?			R			R			R		r		R	Cr	Cr	
199. Callonema imitator														R											
200. Styliola fissurella	C	C	C		C	R														R					
201. Tentaculites bellulus	C									R		R?								R				R	
202. Coleolus tenuicinctum				r		R			R		R				R		R			R			R		
203. Hyolithes aclis				r	R	R			Cr						R				R	R			R		
204. H. striatus																				R	R?			R	
205. Conularia undulata				R					R																
CEPHALOPODA.																									
206. Orthoceras crotalum			R?	r	r?				R						R				R	R	R	R	R	R	R
207. O. cælamen																				R?			R	R	
208. O. nuntium																				R				R	
209. O. subulatum		C?									R?									Cr				r	
210. O constrictum						R	R																		
211. O. exile									R?											R			R	R	
212. O marcellense																									
213. O. sp. undet.		Cr	Cr	r	C	C	R			R			r	r	R	R	R	R		C		R			
214. Nautilus liratus juvenis				R																					

APPENDIX.—*Table showing vertical distribution of faunal zones, with their contained faunules, in the Hamilton formation of Cayuga Lake, New York*—Continued.

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	A	B	C	D	F	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
CEPHALAPODA—continued.																									
215. Nautilus fragments		R	R	Cr	R	r	r		Cr	Cr	r					R	R			r					
216. Gomphoceras sp. undet		R																		C		R			
217. Goniatites discoideus					Cr				R											Cr		R	R	r	
218. G. uniangularis			R						R											R					
CRUSTACEA.																									
219. Proetus rowi												R?													
220. P. microgemma																									R?
221. P. macrocephalus												R													R
222. Homalonotus dekayi				R								Cr													
223. Phacops rana		R	R	Cr	R	R		R	r		R	C		C	Cr	CA	C	A	C	C		R	C	C	r
224. P. cristata var. pipa	R																								
225. Dalmanites boothi			R	C		R	R		R		R	r	r	Cr	Cr	r	Cr	r	Cr	Cr	Cr	R	Cr	Cr	R
226. D. boothi calliteles																							R		r
227. Echinocaris punctata						R			R		R														R
228. Tropidocaris hamiltoniæ															R										

229. Rhinocaris sp																									
230. Mesothyra oceani		R	R																						R
231. Ostracods sp. undet		Cr	Cr		C	r	R		C				R						r		R	R	R		
PLANTÆ.																									
232. Lepidodendron gaspianum			R																						
233. Plant fragments			R	R	R	R	r	r	R						R	R		R		Cr				R	CA
234. Taonurus									C	C	R													A	

INDEX.

Names in italic are synonyms; figures in black-face type are numbers of pages containing description or classification.

O

PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Bulletin No. 206.]

The serial publications of the United States Geological Survey consist of (1) Annual Reports, (2) Monographs, (3) Professional Papers, (4) Bulletins, (5) Mineral Resources, (6) Water-Supply and Irrigation Papers, (7) Topographic Atlas of United States—folios and separate sheets thereof, (8) Geologic Atlas of United States—folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists may be had on application.

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DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

THE ACTION OF AMMONIUM CHLORIDE UPON SILICATES

BY

FRANK WIGGLESWORTH CLARKE

AND

GEORGE STEIGER

WASHINGTON
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1902

CONTENTS.

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., September 26, 1902.

SIR: I have the honor to transmit herewith a memoir by Messrs. Clarke and Steiger on the action of ammonium chloride upon silicates, with the recommendation that it be published as a bulletin. These researches are of great geological importance for the light they throw upon the rational constitution of minerals. They are based on a method which is wholly novel and which is capable of wide application. The work is most creditable to the authors and to the United States Geological Survey.

Very respectfully, your obedient servant,

GEORGE F. BECKER,
Geologist in Charge,
Division of Chemical and Physical Research.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

THE ACTION OF AMMONIUM CHLORIDE UPON SILICATES.

By Frank Wigglesworth Clarke and George Steiger.

INTRODUCTORY STATEMENT.

In a series of investigations by Clarke and Schneider, which were carried out in the laboratory of the United States Geological Survey between the years 1889 and 1892,[a] a number of reactions were studied which shed some light upon the constitution of the natural silicates. Among these reactions two were of peculiar interest, on account of their simplicity and the ease with which they could be applied.

First, in the case of talc, it was found that one-fourth of the silica could be liberated by ignition; and that the fraction thus set free was measurable by solution in aqueous sodium carbonate. This reaction suggests that other acid metasilicates may behave in a similar way, and that we perhaps have a means of discrimination between such salts and other compounds which simulate them. In other words, an acid metasilicate may be experimentally distinguished from a pseudo-metasilicate by the way in which it splits up when ignited. Evidence bearing upon this supposition will be found in the present paper.

The second of the reactions just referred to is that between dry ammonium chloride, at its temperature of dissociation, and various silicates, different minerals being very differently attacked. Some are completely decomposed, others are affected but slightly, and in certain cases substitutions are produced of a most suggestive character. To a certain extent, the two reactions overlap; that is, each one bears somewhat upon the other, and hence both have received consideration in the present series of researches.

In the earlier stages of our work the several silicates which were studied were heated with dry ammonium chloride in open platinum crucibles. The temperature chosen was 350°, at which point the chloride breaks up into gaseous hydrochloric acid and free ammonia,

[a] Bulls. U. S. Geol. Survey No. 78, p. 11; No. 90, p. 11; No. 113, pp. 27, 34.

and in this way partial changes were effected. Later, the heatings were performed in sealed combustion tubes, and then the reaction proved to be much more far-reaching. In nearly every case the material taken for investigation was ground up into one large, uniform sample, upon which all the experiments were performed, and in that way the results obtained are comparable with one another. The few exceptions to this rule of procedure will be noticed at the proper places. In testing for soluble silica, a standard solution of sodium carbonate, containing 250 grams to the liter, was used, and here again the experimental conditions have been kept uniform. So much premised, we may proceed to the description of our investigations, species by species, in detail.

ANALCITE.

Analcite, from many points of view, is a species of peculiar interest, and of late years it has received a great deal of attention. Its formula may be written in various ways, especially as regards the interpretation of its one molecule of water; but evidence too often has yielded before preconceived opinion. Additional evidence is now available, partly from the experiments of Friedel, and partly from the data obtained during the present investigation.

The analcite first examined by us was in well-developed crystals from Wassons Bluff in Nova Scotia. A uniform sample was prepared, as usual, and the analysis, given below, is contrasted with the theoretical composition required by the accepted empirical formula $NaAlSi_2O_6 . H_2O$.

	Found.	Calculated.
SiO_2	57.06	54.55
Al_2O_3	21.48	23.18
Fe_2O_3	.13	
CaO	.16	
Na_2O	12.20	14.09
H_2O at 100°	.58	
H_2O over 100°	8.38	8.18
	99.99	100.00

Fractions of water.

At 100°	0.58
At 180°	1.16
At 260°	3.64
At 300°	1.57
Low redness	1.90
Full redness	.11
Blast	none
	8.96

The fractional water determinations were made by heating in an air bath to constant weight at each temperature up to 300°, and finally over the direct flame. The first fraction, at 100°, is evidently hygroscopic or extraneous water, which can be disregarded. The remainder of the water, 8.38 per cent, belongs to the species. The significance of the analytical figures will be considered later.

Upon boiling the powdered analcite with the standard sodium carbonate solution, 0.73 per cent of silica was extracted. After ignition the mineral in two determinations yielded 1.46 and 1.38 per cent, respectively. The splitting off of silica is, therefore, very slight; and one of the formulæ proposed by Doelter,[a] $Na_2Al_2Si_2O_8+2H_2SiO_3$, may be set aside as improbable. Metasilicic acid, or an acid metasilicate, can hardly be present in analcite; although the possibility of a neutral metasilicate, as indicated by the empirical formula, is not excluded. If Doelter's formula were correct, one-half of the silica should be liberated by ignition.

Upon heating analcite with dry ammonium chloride, notable results were obtained even in an open platinum crucible. Sodium chloride was formed, which could be leached out by water and measured, while ammonia, free from chlorine, was retained by the residue to a notable and surprisingly stable degree. The experiments in detail were as follows:

A. Analcite, mixed with four times its weight of ammonium chloride, was heated for four hours to 350°. There was a gain in weight of 2.18 per cent, and 6.10 per cent of soda, or one-half of the total amount, was converted into NaCl, which was leached out by water, examined as to its purity, and weighed. In the residue 1.20 per cent of silica was extracted by sodium carbonate, showing that no more splitting off had occurred than was previously observed. The gain in weight, as will be seen from subsequent experiments, is due to the fact that all of the NH_4Cl had not been driven off, or else that more water was retained.

B. Analcite was ground up with four times its weight of NH_4Cl, heated for several hours, reground with another fourfold portion of chloride, and heated to 350° for twenty-one hours. Gain in weight, 0.08 per cent. 5.57 per cent of soda was extracted as chloride.

C. Analcite heated to 350° for eight hours with four times its weight of NH_4Cl. Loss of weight, 0.10 per cent.

D. Six grams of mineral and 28 of chloride, mixed by thorough grinding, were heated to 350° for fourteen hours; then were reground with 28 grams of fresh NH_4Cl and heated for thirty-five hours. Loss of weight, 0.13 per cent. 5.07 per cent of soda was extracted as chloride, plus 0.14 of ammonium chloride unexpelled. 2.03 per cent of silica was rendered soluble in sodium carbonate.

So far three facts are noticeable. First, the weight of the mineral after treatment is almost exactly the same as before, showing that gains and losses have balanced each other. Secondly, little silica has been split off. Thirdly, approximately, but not rigorously, one-half of the soda has been converted into NaCl. In A it was exactly half; in the other experiments, a little less than half. Furthermore, in the sodium chloride dissolved out, there is only a very little ammonium

[a] Neues Jahrbuch, 1890, Vol. I, p. 133.

chloride, amounting at most to 0.14 per cent, calculated upon the weight of the original mineral.

In the residue of the analcite after extraction of sodium chloride, abundant ammonia can be detected, with either no chlorine or at most a doubtful trace. If, however, the unleached mineral, still retaining its sodium chloride, be heated strongly, say, from 400° up to redness, NH_4Cl is regenerated and given off. Its absence, as such, both from the leach and the residue was repeatedly proved. The ammonia and water retained by the analcite after heating to 350° with ammonium chloride were several times determined, and the following percentages, still reckoned on the original mineral, were found:

	NH_3.	H_2O.
In B	2.03	2.25
In C	2.19	2.00
In D	2.36	1.89
"	2.35	
"	2.06	
Mean	2.20	2.04

Correcting the ammonia for the 0.14 of NH_4Cl found in D, the mean value becomes 2.15. The determinations of it were made by three distinct methods, and there is no possible doubt as to its presence.

The composition of the analcite after the treatment with ammonium chloride may now be considered, with the subjoined combination of the data. The NaCl in A, 11.50 per cent, was in material which had gained 2.18 per cent, and is subject to a correction which reduces the figure to 11.26. In B, C, and D the corresponding correction is so small that it may be neglected. The last column gives the composition of the leached residue, recalculated to 100 per cent, after deduction of NaCl and the soluble silica. The letters refer back to the several experiments, and the little iron is included with the alumina.

	A.	B.	C.	D.	Average.	Residue.
Sol. SiO_2	1.20			2.03	1.61	
Insol. SiO_2				54.96	54.96	62.59
Al_2O_3				21.37	21.37	24.34
CaO				.16	.16	.18
NaCl	11.26	10.50		9.57	10.44	
Na_2O				7.12	7.12	8.11
NH_3		2.03	2.19	2.21	2.15	2.46
H_2O		2.25	2.00	1.89	2.04	2.32
				99.31	99.85	100.00

The results thus obtained with analcite from Nova Scotia were so remarkable that further investigation seemed to be needed upon material of different origin, and with variation in the details of manipulation. The new experiments, which have led to highly interesting consequences, are now to be described.

To the kindness of President Regis Chauvenet, of the State School of Mines, we are indebted for a liberal supply of well-crystallized analcite from North Table Mountain, near Golden, Colo., of which a uniform sample of about 80 grams was prepared. An analysis of the mineral gave the following results:

SiO_2	55.72
Al_2O_3	23.06
CaO	.17
Na_2O	12.46
H_2O at 100°	0.13
H_2O above 100°	8.26
	99.80

Water by fractions.

At 100°	0.13
At 180°	.75
At 260°	2.44
At 300°	1.28
At 350°	1.76
At redness	2.03
	8.39

Above a low red heat no further loss of weight was observed. Upon boiling the powdered mineral for fifteen minutes with the standard solution of sodium carbonate, 0.45 per cent of silica was dissolved. After ignition, 0.57 per cent was soluble, which is practically the same amount. No silica was split off by heating. The experiments with ammonium chloride fall into two series. The first of these was conducted precisely as in the case of the Nova Scotian material, namely, by grinding the powdered mineral into an intimate mixture with four times its weight of the chloride, and heating in an open crucible. In three cases the material, after volatilization of the ammonium chloride, was reground with a fresh amount of the salt, and then heated again. The temperature and duration of the experiments were purposely somewhat varied. After heating, the material was leached out with water, the sodium chloride which had been formed was estimated, and in the residue the fixed ammonia was determined.

In this series there were four experiments, with results as follows:

	Hours heated.	Temperature.	Soda removed.	Ammonia in residue.
A	28	300	4.75	2.04
B	8½	350	6.36	2.88
C	26	350	3.76	1.72
D	5	340–380	6.70	2.85

In the analcite from Nova Scotia the ammonia retained by the leached residue ranged from 2.03 to 2.36 per cent, while the extracted soda varied from 5.07 to 6.10. In two of the new experiments these figures are perceptibly exceeded, and they represent the shortest duration of heating. Prolonged heating seems to be undesirable, and seems to undo a part of the reaction which has taken place; otherwise the results obtained are of the same order as their predecessors. About one-half of the soda in the analcite is converted into chloride, while variable ammonia is retained.

In the second series of experiments a sealed tube was substituted for the open crucible. The powdered analcite was intimately ground with four times its weight of ammonium chloride, as before, and then heated to 350° in a tube furnace for from four to eleven hours. Under these conditions practically the whole of the soda in the mineral was converted into sodium chloride, while all of the liberated ammonia was absorbed by the residual silicate. Upon leaching the contents of the tube with water, to remove sodium and ammonium chlorides, a residue was obtained which exhibited constant composition whether dried at 100° or at the ordinary temperature of the air. Three samples of the residue were prepared and analyzed; other samples were partially examined and used for subsidiary experiments. The three analyses, lettered for future reference, were as follows, the analcite itself being included in the table for comparison:

	Analcite.	Residue A.	Residue B.	Residue C.
SiO_2	55.72	61.93	61.68	61.79
Al_2O_3	23.06	25.21	25.33	25.24
CaO	.17	....	....	....
Na_2O	12.46	.40	.22	.28
NH_3	....	7.23	6.95	7.71
H_2O	8.39	4.50	4.91	5.01
	99.80	99.27	99.09	100.03

Residue C was prepared with the greatest care, and was air dried. Exposed over sulphuric acid in a vacuum desiccator for fourteen days, it lost in weight only 0.08 per cent. Tested for chlorine, only a slight trace could be recognized, but upon boiling for fifteen minutes with sodium carbonate solution it yielded 1.97 of soluble silica. After ignition only 1.70 of silica was soluble, or somewhat less than before. Upon heating to constant weight at 300°, only 0.46 per cent was lost, but at 350° it slowly decomposed, giving off ammonia. At 300° the compound is stable.

The 0.28 per cent of soda remaining in residue C may be regarded as representing unaltered analcite, doubtless coarser particles which

escaped complete transformation. It corresponds to 1.98 per cent of analcite, which, together with the 1.97 of soluble silica and the 0.46 of water lost below 300°, may be deducted from the substance in order to obtain the composition of the definite compound. The latter amounts to 94.72 per cent of the total residue, and agrees very nearly in composition with the formula

$$2NH_3.H_2O.Al_2O_3.4SiO_2.$$

Recalculating the 94.72 of residue to 100 per cent, we get the following comparison between analysis and theory:

	Found.	Calculated.
SiO_2	61.07	60.92
Al_2O_3	26.15	25.88
NH_3	8.14	8.63
H_2O	4.64	4.57
	100.00	100.00

Written in rational form the compound becomes equivalent to an anhydrous ammonium analcite,

$$NH_4AlSi_2O_6;$$

that is, analcite in which sodium has been replaced by ammonium. From this point of view the reaction between analcite and ammonium chloride becomes a simple case of double decomposition, and is perfectly intelligible. To establish this conclusion, however, corroborative experiments were necessary.

In the first place, the observed equivalency between the sodium lost and the ammonia gained might be due to a mere coincidence, and so far be illusory. One atom of sodium, taking chlorine from ammonium chloride, liberates one molecule of ammonia, the amount which the analcite residue has retained. Suppose more ammonia were present; could it be absorbed?

To answer this question another tube was prepared, with the usual mixture of analcite and ammonium chloride. This was covered by a loose plug of glass wool, in front of which we placed enough pure lime to liberate about double the normal amount of ammonia. The tube was then sealed, and heated to 350°, as in the previous experiments. Upon opening the tube, a strong outrush of ammonia was noticed; but in the leached and thoroughly washed residue, only 7.52 per cent of ammonia was found. This quantity agrees with that from the previous samples, and shows that the limit of the reaction has been practically reached. One molecule of ammonia is retained, and no more.

Still another experiment was tried upon a portion of the residue marked C. If the compound is really an ammonium salt, it should

be decomposable by caustic soda in such a way as to reverse the reaction by which it had been obtained. The substance, however, is very insoluble, so that the reaction takes place slowly. To phenol phthalein it is absolutely neutral, and with Nessler's reagent it reacts only after long standing.

To settle the question a weighed portion of the compound was boiled in a distilling flask with a 10 per cent solution of sodium hydroxide, to which water was added from time to time. The distillate was collected in a tube containing aqueous hydrochloric acid; and the ammonia which passed over was weighed, ultimately as chloroplatinate. By four hours' boiling 6.90 per cent of ammonium was driven off and determined; and the residue remaining in the flask, after washing until no alkaline reaction could be detected in the washwater, was examined for soda, of which 10.41 per cent was found. The anticipated reaction had taken place, although not completely; it was enough, however, to confirm our opinion, and to establish the nature of the new compound beyond reasonable doubt. Other confirmation was obtained later, from the study of leucite.

The foregoing paragraphs now enable us to understand a phenomenon which we observed in our work with the open crucible. In that case a partial reaction takes place between the analcite and the ammonium chloride, producing, as in the sealed tube, a mixture of an ammonium alumino-silicate with sodium chloride: the two substances being separable by leaching. But if, instead of leaching, the mixture be heated to full redness, ammonium chloride is re-formed and given off, leaving a residue which contains little or no sodium chloride, and is wholly insoluble, or almost so, in water. That is, the reaction which occurs at 350° is reversed at the higher temerature, and anhydrous analcite, or an isomer of it, is regenerated. Ammonium and sodium again change places, and the original state of molecular equilibrium is restored.

What, now, is the nature of the product obtained in the open crucible after sodium chloride has been removed? Is it a definite intermediate compound or an indeterminate mixture? At first we were inclined to accept the first of these alternatives, and we assigned to the substance the formula $H_2Na_2Al_4Si_8O_{24}.NH_3$, in which the ammonia plays a part equivalent to that of water. In this expression we were influenced by the researches of Friedel,[a] who had shown that ammonia could in part replace the "zeolitic" water of analcite; but it now appears that the phenomenon observed by him is quite distinct from that discovered by us, and is, indeed, of an entirely different order. We may, therefore, in accordance with our new data, rearrange the formula, transforming it to that of an ammonium salt, $HNa_2NH_4Al_4Si_8O_{24}$, the agreement with the analytical figures being approximate only. The results obtained are not sharp enough for certainty.

This product we are now inclined to regard as a mixture, although

[a] Bull. Soc. min. France, Vol. XIX, p. 94, 1896.

it is not strictly intermediate between analcite and its final ammonium derivative. Only half of the eliminated sodium has been replaced by ammonium, while hydrogen, or water, makes up the deficiency. It seems probable that the reaction in the sealed tube and that in the open crucible are at first essentially the same, but that in the latter case secondary reactions follow, which cause the variations in the final results. In the sealed tube the element of pressure comes into play, and the reaction is complete. In the open crucible pressure is lacking; some ammonia escapes fixation and reacts upon a part of the sodium chloride which was at first formed; hence the composition of the leached residue is essentially modified. This residue may be a definite compound, but the case in its favor is unproved and the presumption is rather against it.

The most remarkable fact developed by the foregoing experiments is the easy replaceability of the soda in analcite. This replaceability, however, is not limited to the substitution of ammonium for sodium; it appears to extend to other bases as well, and this we have proved in the case of silver. This is illustrated by three experiments upon the Colorado analcite, as follows:

A. Analcite, intimately mixed with dry silver nitrate, was heated in a sealed tube to 400° for four hours.

B. Analcite and silver nitrate were heated in a sealed tube to 250° for four hours.

C. Ammonium analcite, mixed with dry silver nitrate, was heated in a sealed tube to 250° for four hours.

All the products of these heatings were leached with water, and washed until the filtrates gave no test for silver; the residues were then dried on the water bath. The product in each case was a white powder not differing in appearance from the original material.

The analyses of the different portions are given below, together with the composition of the theoretical compound, $AgAlSi_2O_6.H_2O$, which is given in column D.

	A.	B.	C.	D.
SiO_2	41.31	40.08	42.69	39.35
Al_2O_3	16.44	16.29	18.22	16.72
Ag_2O	37.45	36.91	32.01	38.03
Na_2O	.85	.81	.68	....
H_2O	4.29	5.86	6.08	5.90
NH_3	....	....	.69	....
Nitrates	none	none	none	....
	100.34	99.95	100.37	100.00

From preparation A, 13.13 per cent of the soda in the original mineral was found in the leach water; and in B, 12.57 per cent. These quantities are slightly in excess of the amount actually present in the analcite, for the reason that a little other material which passed into

the filtrates was not separated from the soda. It is enough to show that a true silver analcite has been formed, and that the transformation is practically complete. A similar reaction takes place between silver nitrate and chabazite, but the product as yet has not been exhaustively examined. The reaction, it will be observed, is analogous to that by which silver ultramarine is produced, and it suggests a promising line of experimentation for the future.

LEUCITE.

Between analcite and leucite the closest analogies have long been recognized. The two minerals have similar composition, they resemble each other in crystalline form, and they yield, upon alteration, products of the same order. Recently also, analcite, like leucite, has been identified as a not uncommon constituent of volcanic rocks; analcite basalt being a good example. In view of these resemblances it was plainly desirable to compare the minerals by means of the ammonium chloride reaction, a task which has been performed with satisfactory results.

In a preliminary experiment a sample of leucite taken without regard to purity was heated with ammonium chloride to 350° in a sealed tube. Potassium chloride was formed corresponding to 18.06 per cent of potash, and in the leached residue 6.90 per cent of ammonia was found. The foreseen reaction had occurred, and more careful work was accordingly undertaken.

Our material consisted of a large, irregular crystal of leucite from Vesuvius, which yielded about 20 grams of the pure mineral. This was ground to a uniform sample, and a portion of it was analyzed; the analysis will be given presently. The sealed-tube experiments were conducted precisely as in the case of analcite, and they confirmed both the preliminary test and our anticipations. Chlorides were formed equivalent to 18.53 per cent of potash, 1.08 of soda, and 0.08 of alumina; the reaction, therefore, was very nearly complete. The leached residue was then analyzed, and the data, compared with the analysis of the original mineral, were as follows:

	Leucite.	Residue.
SiO_2	55.40	60.63
Al_2O_3	23.69	26.44
CaO	.16	trace
K_2O	19.54	.50
Na_2O	1.25	.25
NH_3		7.35
H_2O	.24	5.17
	100.28	100.34

Leucite, then, gives the same reaction as analcite and yields the same ammonium compound. A closer agreement in the composition of the latter could not reasonably be demanded. Ammonium leucite is formed in both cases by ordinary double decomposition in a state of approximate purity; the first silicate of ammonium, we think, which has ever been prepared.

As a further check upon the results so far obtained, an attempt was made to transform ammonium leucite into the corresponding lime salt, $CaAl_2Si_4O_{12}$, by fusion with calcium chloride. The ammonium leucite was mixed with a saturated solution of calcium chloride, which was evaporated to dryness, then heated gradually to dehydration, and finally fused. Ammonium chloride was given off and identified. Upon treating the fused mass with water, filtering and thoroughly washing the residue, a white powder was obtained which, after drying at 100°, was analyzed. It was also examined microscopically by Mr. J. S. Diller, who found it to consist of apparently isotropic grains, showing traces of incipient crystallization. The following analysis is contrasted with the theoretical composition of calcium leucite, from which it varies considerably.

	Found.	Calculated.
SiO_2	54.35	60.30
Al_2O_3	26.23	25.63
CaO	17.38	14.07
K_2O	.16	
Na_2O	.25	
Cl	.28	
Loss on ignition	1.24	
	99.89	100.00

Evidently the desired salt was not definitely obtained, and the product appears to be a mixture. The reaction, however, tends in the right direction, and deserves further study under other conditions. Probably the water which was present in the mixture of silicate and chloride took part in the changes produced, although of this we can not be certain. It is interesting to note that the product obtained approximates in composition to the meteoric mineral maskelynite, which is regarded by Groth as probably equivalent to a calcium leucite.

THE CONSTITUTION OF ANALCITE AND LEUCITE.

In all of the earlier attempts to discuss the constitution of analcite the molecule of water which it contains has been a chief element of uncertainty. Should it be regarded as representing hydroxyl or as

water of crystallization? That question arose first of all. Under the first interpretation analcite became a diorthosilicate: $AlNaH_2Si_2O_7$; under the latter its equivalency with leucite appeared. The researches of Friedel, however, have settled this question in part, and whatever the function of the water may be it is something outside of the true chemical molecule; for all the water can be expelled from analcite by heat, without destruction of the crystalline nucleus, the anhydrous salt, and it is taken up again upon exposure of the dehydrated mineral to moist air. But whatever its mode of union may ultimately prove to be, the amount of water in analcite corresponds to the simple molecular ratio which is shown in the ordinary formula of the species. One molecule of analcite holds a certain definite number of water molecules, and Friedel's observations are not incompatible with the idea that these are retained with varying degrees of tenacity. This idea is suggested by the various series of fractionation experiments which have been made from time to time by independent workers, even though the data are not by any means concordant. Thus Lepierre[a] found that half the water of analcite was driven off at or below 300°, the other half above 440°. In our own experiments three-fourths were expelled at 300°, the remaining fourth being held up to a much higher but undetermined temperature. In both series the water fractions are represented by fourths, but Friedel's experiments[b] indicate a continuity of loss in weight of a quite dissimilar order. Friedel holds that all of the water fractionations heretofore made upon analcite are fallacious, and that no definite fractions can be identified—a conclusion strongly supported by his own data, even though the proof is not absolutely positive. The most that can be said is that the weight of evidence so far is in favor of Friedel's contention, but that additional investigation is necessary in order to reconcile all discrepancies. The full significance of the water in analcite remains unknown.

Eliminating the water from analcite, the empirical formulæ for both analcite and leucite appear at once to be identical in form and to represent salts of ordinary metasilicic acid. Indeed, both minerals have been commonly regarded as metasilicates; but upon this point the production of the ammonium derivatives now sheds a new light. In the formation of the latter compounds the fixed bases of the original salts have been replaced by a volatile base, and the substances so formed split up upon ignition in such a way as to give evidence regarding their constitution.

For example, if ammonium leucite is a true metasilicate, a salt of the acid H_2SiO_3, it should break up, when ignited, in accordance with the following equation:

$$2NH_4Al(SiO_3)_2=Al_2(SiO_3)_3+2NH_3+H_2O+SiO_2;$$

[a] Bull. Soc. chim. France, 3d series, Vol. XV, p. 561, 1896.
[b] Bull. Soc. min. France, Vol. XIX, p. 363, 1896.

that is, one-fourth of the silica ought to be set free, measurable by extraction with sodium carbonate solution. No such splitting off occurs, however. An ammonium leucite which already contained 1.97 per cent of soluble silica gave only 1.70 per cent after ignition; hence no additional silica had been liberated. We may conclude, therefore, that analcite and leucite are not true metasilicates, but pseudo-compounds, either salts of a polymer of metasilicic acid or mixtures of ortho- and trisilicates analogous to those which we find among the plagioclase feldspars and in the mica group.

In order to discuss the constitution of analcite, let us recur to our analysis of the variety from Nova Scotia. It is at once evident from the comparison made on a preceding page that our sample of the mineral varies notably in composition from the requirements of theory. The silica is 2½ per cent too high, while alumina and soda are correspondingly low. No probable impurity and no presumable errors of manipulation can account for so great a divergence. If we consult other analyses, as we find them tabulated in manuals like those of Dana and Hintze, we shall find other cases resembling this, and also examples of variation in the opposite direction, with silica low and an apparent excess of bases. Most analcite gives quite sharply the metasilicate ratios required by the accepted formula; but the variations from it are large enough, common enough, and regular enough to command attention. The analyses are not all covered by the recognized theory, and the apparent irregularities are not fortuitous, but are systematic in character.

One explanation of the seeming anomalies is simple and clear. If analcite, instead of being a metasilicate, is really a mixture of ortho and trisilicate, then all of the analyses become intelligible. In most cases the two salts are commingled in the normal ratio of 1:1, but in our analcite the trisilicate predominates, while in some other samples the ortho-salt is in excess. All reduce alike to the simple expression

$$NaAlX.H_2O,$$

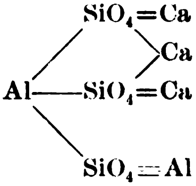
in which X represents $nSiO_4+mSi_3O_8$, a formula which agrees with evidence from various other sources.

For example, analcite may be derived in nature either from albite, $AlNaSi_3O_8$, or nephelite, $AlNaSiO_4$, and on the other hand alterations of it into feldspars have been observed. Its closest analogue, leucite, has yielded pseudomorphs of orthoclase and elæolite, while leucite and analcite are mutually convertible each into the other. The evidence of this character—the evidence of relationship between analcite and other species—is varied and abundant, and the simplest conclusion to be drawn from it is that which has been given. Every alteration, every derivation, every variation in the composition of analcite points to the same belief. The consistency of the data can not well be denied.

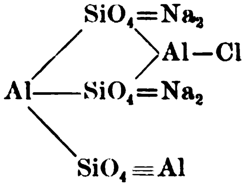
In the case of a normal analcite—that is, one which conforms to the usual empirical formula—the expression which best represents these relations is

$$Al_4Na_4\,(SiO_4)_2\,(Si_3O_8)_2 .\ 4H_2O;$$

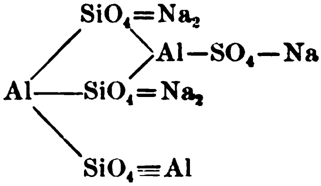
and leucite is the corresponding potassium salt, but anhydrous. Structurally this is comparable with the formulæ of garnet, zunyite, sodalite, and noselite, all of which are isometric in crystallization. The more important of the symbols are as follows:



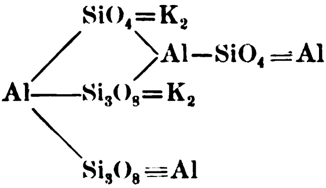
Garnet.



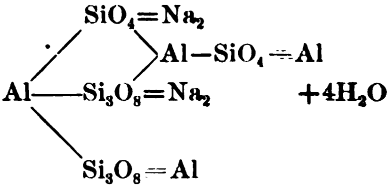
Sodalite.



Noselite.

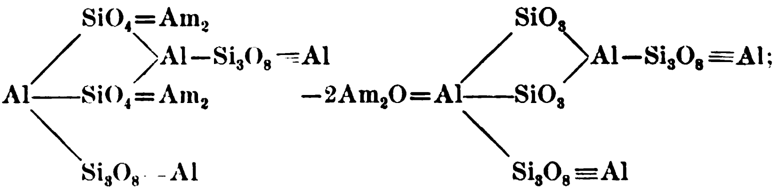


Leucite.



Analcite.

That is, analcite and leucite become members of the garnet-sodalite group of minerals, and their relations to nephelite, albite, etc., natural and artificial, are perfectly clear. In analcite there may be admixtures of strictly analogous ortho- or trisilicate molecules; but these remain to be separately discovered. The ammonium salt corresponding to such a mixture, when ignited, might be expected to give the following reaction:



a reaction which is in harmony with our experimental results. In it no free silica appears; and many, if not all, conditions of the problem are satisfied. One difficulty, however, stands in the way of an unqualified acceptance of these formulæ. Garnet, sodalite, nephelite, albite, etc., are but moderately attacked by ammonium chloride, and so far have yielded no definite ammonium derivatives. Whether this difference in behavior is constitutional or not it is hardly possible to say, but it must be taken into account in connection with all of the other evidence. We must remember, moreover, that the formulæ

are not ultimate verities to be blindly accepted. They are simply expressions which represent composition and a wide range of established relationships, and which serve a distinct purpose in the correlation of our knowledge. Properly used, with due recognition of their limitations, they are helpful, and suggest possibilities of research; misused, they may become mischievous. They now satisfy most of the known conditions, and that is a sufficient warrant for their existence.

POLLUCITE.

On account of the general analogy between pollucite, analcite, and leucite, the first-named species of the three seemed to deserve some attention. Through the kindness of Prof. S. L. Penfield, about 10 grams of very pure material from Hebron, Me., was put at our disposal, and three analyses of it by Wells were already on record.[a] The average of these analyses is as follows:

SiO_2	43.53
Al_2O_3	16.37
CaO	.22
Na_2O	1.81
K_2O	.49
Li_2O	.04
Cs_2O	36.08
H_2O	1.52
	100.06

Five grams of the finely powdered mineral was heated in a sealed tube with four times its weight of ammonium chloride to 350° during forty hours. Upon leaching with water 0.14 per cent of CaO, 1.28 of Na_2O, and 12.30 of Cs_2O were extracted. Probably the calcium chloride formed contained some potassium chloride, but that point was ignored as irrelevant. The air-dried residue had the following composition:

SiO_2	49.21
Al_2O_3	18.32
CaO	none
Cs_2O (K_2O)	28.84
Na_2O	none
NH_3	2.52
H_2O	1.91
	100.80

The high summation here is due to reckoning some KCl as CsCl. Of the silica in this product 2.36 per cent was soluble in the standard solution of sodium carbonate. After ignition, 4.13 per cent was soluble. Some silica, therefore, was split off by heating.

[a] Am. Jour. Sci., 3d series, Vol. XLI, p. 213, 1891.

In a second experiment one gram of pollucite was heated with ammonium chloride for five hours, the other conditions being the same as before. Upon leaching, 11.55 per cent of Cs_2O was extracted, and a partial analysis of the air-dried residue gave the following data:

SiO_2	47.87
Al_2O_3	17.85
NH_3	2.83
H_2O	1.55
Alkalies (by difference)	29.90
	100.00

The two products were evidently the same, and only about one-third of the alkalies in the pollucite had been extracted. So, also, the ammonia taken up was only about one-third of that which was retained by analcite and leucite. The transformation, then, is merely partial, and further experimentation seems to be unnecessary, at least for present purposes. The analogy with analcite and leucite is far from perfect.

NATROLITE.

In a preliminary experiment upon an impure, yellowish natrolite from Aussig in Bohemia, we found that this species was peculiarly well suited to reaction with ammonium chloride. By heating with the reagent in a sealed tube and subsequent leaching with water, 17.56 per cent of bases was extracted, and in the residue 8.29 per cent of ammonia was found. Careful work upon this species was therefore desirable.

The material available for our experiments came from the well-known locality at Bergen Hill, N. J., and consisted of a mass of slender needles densely matted together. Part of the uniform, ground sample was analyzed, with fractional determinations of the water, and part was used for the sealed tube experiments, precisely as in the research upon analcite and leucite. Three of these experiments were made, and in each case the natrolite was mixed by grinding in an agate mortar with four times its weight of dry ammonium chloride, after which it was heated to 350° in the sealed tube. Even during the grinding a slight reaction took place, and a distinct smell of ammonia was given off by the mixture. With pectolite the same smell was perceived. The three experiments may be summarized as follows:

A. Heated eleven hours. Upon leaching, 14.89 per cent of soda and 1.20 of lime were extracted. In the residue 9.26 per cent of ammonia was found.

B. Heated nine hours. Leach not examined. 9.26 of ammonia in residue. The complete analysis of the residue is given farther on.

C. Heated three hours. 14.09 per cent of soda and 0.20 of lime were extracted. The residue contained 8.87 per cent of ammonia. In this instance the heating

was relatively brief, in order to learn whether its duration could be advantageously lessened. The reaction was evidently less complete than in experiments A and B.

In the subjoined table we give first the analysis of the natrolite itself, and then that of the leached residue from experiment B. In the latter we found that 0.86 per cent of silica was soluble in sodium carbonate solution, and that soda and lime remained corresponding to 4.61 per cent of the original mineral. Deducting these impurities, together with the 0.42 per cent of hygroscopic water, and recalculating to 100 per cent, we get the *reduced* composition of the residue. In the last column is given the calculated composition of an anhydrous ammonium-natrolite, $(NH_4)_2Al_2Si_3O_{10}$. This compound has evidently been formed to an extent represented by over 94 per cent of the leached natrolite residue. The agreement between theory and even the unreduced analysis is practically conclusive on this point.

	Natrolite found.	Residue found.	Residue reduced.	$(NH_4)_2Al_2Si_3O_{10}$ calculated.
SiO_2	46.62	53.71	53.86	54.06
Al_2O_3	26.04	29.94	30.52	30.43
CaO	1.48	.34		
K_2O	none			
Na_2O	15.67	.37		
NH_3		9.26	9.85	10.14
H_2O at 100°	.39	.42		
H_2O above 100°	10.18	5.94	5.77	5.37
	100.38	99.98	100.00	100.00

The fractional water determinations will be given later, in connection with similar data for scolecite (p. 25).

It may not be superfluous to note that the water given in the last two columns of the foregoing table represents the difference between ammonia and the hypothetical ammonium oxide which has replaced soda.

Two other experiments upon natrolite remain to be noticed. First, the fresh mineral was boiled for fifteen minutes with a 25 per cent sodium carbonate solution; 0.72 per cent of silica dissolved. Similar treatment of ignited natrolite took out 0.62 per cent. No silica is split off by ignition. Ammonium natrolite before ignition yielded 0.85 per cent of soluble silica, and after ignition 0.86 per cent. Here again no silica had been split off from the molecule, and practically none was liberated by the action of the ammonium chloride upon the natrolite. A simple, direct substitution of ammonium for sodium had occurred.

Heated with ammonium chloride in an open crucible, natrolite gives only a partial reaction. This is shown by the earlier experiments of Schneider and Clarke upon natrolite from Magnet Cove, Arkansas, from which, by a triple heating with the reagent, only 9.50 per cent of soda was extracted out of a total of 15.40.

SCOLECITE.

On account of the well-recognized analogy between natrolite and scolecite, the latter mineral seemed to be peculiarly worthy of examination. The specimen at our disposal was a mass of stout, radiating needles, which was collected by one of us at Whale Cove, on the island of Grand Manan, New Brunswick. Scolecite, we believe, has not hitherto been recorded from this locality, and on this account alone the material deserved attention.

Three sealed tube experiments were carried out, essentially as in the case of natrolite, as follows:

A. Heated ten hours at 350°. 13.74 per cent of lime and 0.35 of soda were taken out. The residue contained 8.78 per cent of ammonia.

B. Heated ten hours at 370°. 12.97 of lime and 0.22 of soda were extracted. 8.48 per cent of ammonia in the residue. On account of the excessive temperature of this experiment, some reversion of the converted material had taken place.

C. Heated five hours at 340°–350°. Leach not studied. 8.91 per cent of ammonia in residue.

Analyses of the scolecite and of residues B and C are given below. The less perfect transformation in the case of B is evident.

	Scolecite.	Residue B.	Residue C.
SiO_2	45.86	53.39	53.69
Al_2O_3	25.78	30.51	30.50
CaO	13.92	.62	.42
Na_2O	.41	undet.	.29
NH_3	......	8.48	8.91
H_2O at 100°	.40	.74	.12
H_2O above 100°	13.65	6.28	6.52
	100.02	100.02	100.45

The product of the reaction is plainly the same as that obtained from natrolite, and the identity in type of the two species is perfectly clear. This fact is further emphasized by an experiment upon the solubility of silica. The fresh scolecite gave up 0.36 per cent of silica to sodium carbonate solution, and the ignited mineral yielded only 0.50 per cent. Again, natrolite and scolecite behave in the same way.

Upon both minerals fractional determinations of the water were made, and the amount lost at each temperature was noted. The

results, expressed in percentages of the original minerals, were as follows:

Temperature.	Water lost.	
	Natrolite.	Scolecite.
100°	0.39	0.40
180°	.40	.52
250°	.37	4.76
350°	8.51	.55
Incipient redness	.72	7.72
Full redness	.12	.04
Over blast	.06	.06
	10.57	14.05

Scolecite contains one more molecule of water than natrolite, and that amount, one-third of its total, seems to go off at a lower temperature than the other two molecules. Otherwise the two series of experiments are probably not far apart, and they indicate that the water is in neither case constitutional. The same conclusion is suggested by the existence of the anhydrous ammonium compound, the three formulæ being as follows:

Scolecite	$CaAl_2Si_3O_{10}.\ 3H_2O$
Natrolite	$Na_2Al_2Si_3O_{10}.\ 2H_2O$
Ammonium natrolite	$(NH_4)_2Al_2Si_3O_{10}$

The parallelism is complete; and all three compounds are evidently salts of an acid, $H_8Si_3O_{10}$, which is probably orthotrisilicic acid, $Si_3O_2(OH)_8$. The relations of this acid to its anhydrides will be considered later.

PREHNITE.

In a former bulletin upon the constitution of the silicates,[a] one of us attempted to show that natrolite, scolecite, and prehnite were similar in chemical structure, provided that all or part of their water was regarded as constitutional. The formulæ then assigned were as follows:

Scolecite	$Al_2(SiO_4)_3CaH_4.\ H_2O$
Natrolite	$Al_2(SiO_4)_3Na_2H_4$
Prehnite	$Al_2(SiO_4)_3Ca_2H_2$

Two of these formulæ must now be abandoned, because of the experimental evidence which we have obtained, but the prehnite remains to be considered.

[a] Clarke, F. W., Bull. U. S. Geol. Survey No. 125, p. 45, 1895.

The material chosen for examination was an old specimen of prehnite from Paterson, N. J. The analysis of it, with fractional water determinations, is given below:

SiO_2	42.31
Al_2O_3	19.95
Fe_2O_3	6.20
FeO	none
CaO	26.63
H_2O	5.02
	100.11

Fractional water.

At 100°	0.21
At 180°	.18
At 250°	.10
At 350°	.11
Incipient red heat	.28
Full red heat	4.05
Over blast	.09
	5.02

With sodium carbonate sulution, 0.38 per cent of silica was extracted from the fresh mineral. From the ignited prehnite, 1.22 per cent was taken out. Very little silica, therefore, is liberated by ignition.

Two determinations were made of the action of ammonium chloride, as follows:

A. Heated eight hours. On leaching with water, 1.31 per cent of lime and 0.17 of alumina dissolved.

B. Heated twelve hours. 1.41 per cent of lime was extracted, and in the washed residue 0.22 per cent of ammonia was found.

Prehnite, therefore, differs widely from natrolite and scolecite in its behavior with ammonium chloride. Very little action takes place, even upon long heating to 350° in a sealed tube, and practically no ammonia is absorbed. The water is more firmly held than was the case with the other two minerals, and is almost certainly to be regarded as constitutional. The orthosilicate formula for prehnite is unaffected by these results, and may stand as fairly probable. Prehnite can not be correlated with natrolite and scolecite on any basis of similar chemical structure.

THE TRISILICIC ACIDS.

We have already shown that natrolite and scolecite are probably salts of an orthotrisilicic acid, $H_8S_3O_{10}$, an acid which is not particularly well known. As it has interesting relations to other compounds, some discussion of its constitution and its derivatives may not be out of place here.

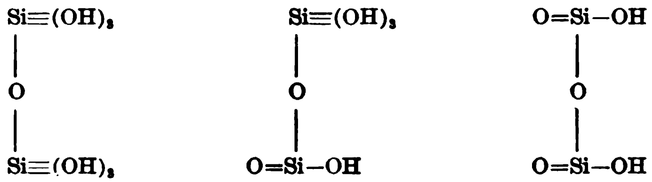
The general theory of the silicic acids is extremely simple. Silicon being a quadrivalent element, its normal acid, the orthosilicic, is

$Si(OH)_4$. From this, by successively eliminating two molecules of water, two anhydrides may be derived, thus:

Orthosilicic acid	$Si(OH)_4$
First anhydride, metasilicic acid	$O{=}Si{=}(OH)_2$
Second anhydride, silicon dioxide	$O{=}Si{=}O$

These acids, containing one atom of silicon each, may be called the monosilicic acids, and some of their salts are perfectly well known. Olivine and anorthite, for instance, are orthosilicates, while the true metasilicates are represented by talc and pectolite. The evidence in the case of the last-named mineral will be presented later.

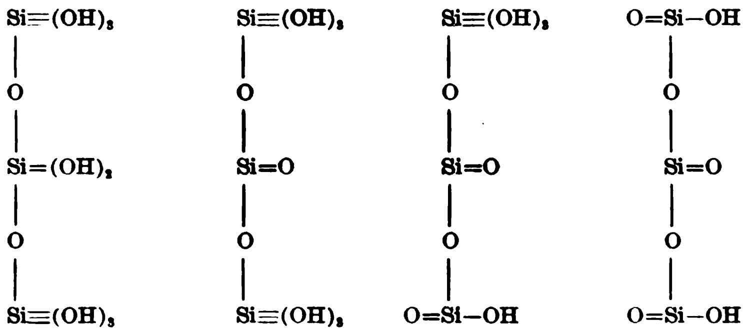
When two molecules of orthosilicic acid coalesce, with elimination of water, an orthodisilicic acid is formed, and this is the first member of another series, as follows:



Orthodisilicic acid. *Metadisilicic acid.* *Pyrosilicic acid.*

To the first and third of these acids various minerals correspond. The second acid, however, is a polymer of metasilicic acid, but differs from the latter in its possible derivatives. When an acid metasilicate is heated silica is set free, but in the case of a metadisilicate this would not necessarily occur. Possibly leucite and analcite may be metadisilicates, although the evidence so far presented does not support this view. The possibility, however, we are compelled to recognize as one which might ultimately be verified.

With the coalescence of three orthosilicic molecules a series of trisilicic acids begins, and one of these forms salts—the feldspars—which are the most abundant compounds existing in the mineral kingdom. The acids of the series are these:



Orthotrisilicic acid. *Metatrisilicic acid.* *Trisilicic acid.* *Third anhydride.*

The third anhydride represents an acid to which no known salts correspond. One step further and we have a fourth anhydride, Si_3O_6, or empirically SiO_2, which may or may not be the true formula of quartz. Quartz is undoubtedly a polymer of SiO_2; its most frequent associates are trisilicates—the feldspars—and hence the formula Si_3O_6 has a certain degree of plausibility. This suggestion, however, is purely speculative and has no definite scientific value. Its validity would be most difficult to establish.

From the first of these trisilicic acids natrolite and scolecite appear to be derived. If we ignore the "zeolitic water," which is not a part of the essential silicate molecule, the two compounds may be formulated thus:

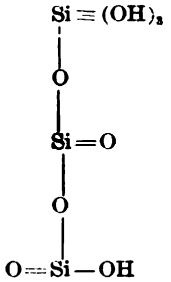
$$\begin{array}{lcl}
Si\equiv O_3\equiv Al & \qquad & Si\equiv O_3\equiv Al \\
\;| & & \;| \\
O & & O \\
\;| & & \;| \\
Si=O_2=Na_2 & & Si=O_2=Ca \\
\;| & & \;| \\
O & & O \\
\;| & & \;| \\
Si\equiv O_3\equiv Al & & Si\equiv O_3\equiv Al \\
\textit{Natrolite.} & & \textit{Scolecite.}
\end{array}$$

So far, no other salts of this acid have been clearly identified.

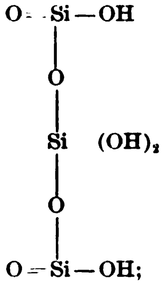
The second acid of the series, like the second of the disilicic acids, is a polymer of the ordinary metasilicic compound. It is well understood that many so-called metasilicates are not representatives of the simple acid H_2SiO_3; some of them are mixtures of orthosilicates with salts of the third acid in this group, $H_4Si_3O_8$; others may be derived from polymers like that which is now under consideration. For example, anhydrous analcite and jadeite are both represented by the empirical formula $NaAlSi_2O_6$, but they differ widely in density, in solubility, and doubtless also in crystalline form. One molecule, then, is much more condensed than the other. If analcite should prove to be a metadisilicate, then jadeite may be its equivalent in the trisilicic series, or it may belong with some still higher polymer. The possibilities are many, but to establish any one of them by proof would demand more evidence than is yet in our possession.

The third member of the trisilicic series is the most important of all, for among its salts are the two feldspars, albite and orthoclase, which together make up fully one-half of the solid crust of the earth. It is also noteworthy from the fact that its formula can be so written

as to represent two isomeric forms, to which distinct salts probably correspond. The two formulæ are as follows:



and



and their significance is clear when we remember that the ordinary trisilicates are commonly dimorphous. Thus we have orthoclase and soda orthoclase, monoclinic; and albite and microcline triclinic; one pair perhaps belonging to one isomer, the other to the other. The rare minerals eudidymite and epididymite, which are also isomeric trisilicates, further illustrate the same conception; but we can not as yet assign either compound distinctly to either formula.

By an extension of the process herein developed, which is by no means new, higher polysilicic series may be formulated. Since, however, such acids correspond to no definitely known salts, to write their formulæ would be a useless exercise of the imagination. Beyond the trisilicic acids we enter the region of the unknown.

STILBITE.

The specimen selected for study was a nearly white, typical example from Wassons Bluff, Nova Scotia. The analysis and the fractional water determinations were as follows:

SiO_2	55.41
Al_2O_3	16.85
Fe_2O_3	.18
MgO	.05
CaO	7.78
Na_2O	1.23
H_2O	19.01
	100.51

Fractional water.

At 100°	3.60
At 180°	6.46
At 250°	3.80
At 350°	2.10
Low redness	2.95
Full redness	.06
Over blast	.04
	19.01

On boiling with sodium carbonate, 1.37 per cent of silica went into solution. After ignition, only 1.03 per cent was obtained. No silica, therefore, is split off when stilbite is ignited. If the mineral were a hydrous acid metasilicate, $H_4CaAl_2Si_6O_{18}.4H_2O$, as has been assumed by some authorities, one-third of the silica should have been set free. Hence the metasilicate formula is to be regarded as unsatisfactory. The evidence here presented counts for something against it.

Two samples of the ammonium chloride derivative were prepared. In leaching with water the insoluble residue was washed until the washings gave no reaction for chlorine. The chlorine shown in the subjoined analyses is, therefore, present in an insoluble form and not as adhering ammonium chloride. Dried at 50° the two products gave the following composition:

	A.	B.
SiO_2	60.80	60.67
Al_2O_3	18.36	18.25
CaO	1.86	1.46
Na_2O	.08	.15
NH_3	5.12	5.13
H_2O	12.96	13.91
Cl	1.31	1.04
	100.49	100.61
Less O	.29	.23
	100.20	100.38

Sample B was further examined as to the presence of soluble silica, and 1.52 per cent was found. After ignition, only 1.62 per cent went into solution. These results conform to those obtained with the original stilbite, and tend to show that the ammonium derivative is a compound of the same order. In the case of the unignited substance the residue remaining after the removal of soluble silica was thoroughly washed, and then examined for alkali. It was found to contain 9.30 per cent of soda, which shows that the ammonium salt had been transformed back into the corresponding sodium compound.

From the foregoing facts it is clear that stilbite, like the zeolites previously studied, is converted by the action of ammonium chloride into an ammonium salt. That is, sodium and calcium are removed as chlorides, ammonium taking their place to form ammonium stilbite. The reaction, however, is less complete than it was in the cases of analcite and natrolite, but whether this is due to a greater stability of the stilbite molecule or only to a different degree of fineness in the powder upon which the operations were performed, we can not say. Neither have we any explanation to offer of the retention of chlorine

by the ammonium derivative. Although the amount of chlorine is small, it needs to be accounted for.

If we discuss the composition of the stilbite and of its ammonium derivative, the relations between them become very clear. Neglecting the water as "zeolitic," to use Friedel's phrase, and, therefore, as not a part of the chemical molecule, and also rejecting the 1.37 per cent of soluble silica as probably an impurity, the ratios derived from the analysis give this empirical formula for the mineral:

$$Na_{40}Ca_{140}Al_{332}Si_{901}O_{2460}.$$

This corresponds to a mixture of ortho- and trisilicates in which $Si_3O_8:SiO_4::286:43$; and uniting these radicles under the indiscriminate symbol X, we have, as a more general expression,

$$Na_{40}Ca_{140}Al_{332}X_{326};$$

or combining monoxide bases,

$$R''_{160}Al_{332}X_{329},$$

which is essentially $R''Al_2X_2$. Since the SiO_4 groups are practically equal in number to the sodium atoms, the stilbite is probably a mixture, very nearly, of $NaAlSiO_4$ and $CaAl_2(Si_3O_8)_2$ in the ratio of 1:7 This is in accordance with the well-known theory of Fresenius as to the constitution of the phillipsite group, to which stilbite belongs. Stilbite is mainly a hydrous calcium albite, commingled with varying amounts of corresponding orthosilicates of soda and lime.

For the ammonium derivative similar relations hold. Taking analysis "B" for discussion, rejecting soluble silica and chlorine as impurities, and neglecting all water except that which belongs to the supposable ammonium oxide, the ratios give this formula:

$$(NH_4)_{301}Na_4Ca_{26}Al_{358}Si_{985}O_{2684}.$$

Uniting sodium and calcium with ammonium, this becomes

$$R'_{357}Al_{358}(Si_3O_8)_{314}(SiO_4)_{43};$$

or, more generally,

$$R'_{357}Al_{358}X_{357}, = 1:1:1.$$

The derivative, therefore, is a compound of the same order as the original stilbite, with the ratio of 1:7 still holding between the ortho and trisilicate groups. This conclusion, however, ignores the presence of chlorine, and is, therefore, inexact to some extent. We are not dealing with ideally pure compounds.

HEULANDITE.

Pure, white heulandite from Berufiörd, Iceland, was the material taken for investigation. Upon boiling with sodium carbonate, 1.73 per cent of silica went into solution. From previously ignited heulandite, only 1.14 per cent was extracted. No silica, therefore, was liberated upon ignition, and a hydrous metasilicate formula for the mineral seems to be improbable. Only one lot of the ammonium

chloride derivative was prepared, and its composition, together with that of the heulandite, is given below.

	Heulandite.	Ammonium salt.
SiO_2	57.10	61.24
Al_2O_3	16.82	18.00
MgO	.07	....
CaO	6.95	2.56
SrO	.46	....
Na_2O	1.25	.60
K_2O	.42	
NH_3	....	4.42
H_2O at 100°	3.61	13.63
H_2O above 100°	13.00	
	99.68	100.45

Here, again, we have the same kind of transformation as before, but rather less complete than in the case of stilbite. That the ammonium taken up is equivalent to the bases removed is shown by a study of the ratios. Ignoring water and the soluble silica, the heulandite ratios are as follows:

$$R'_{48}R''_{130}Al_{330}Si_{923}O_{2495},$$

or, uniting bases,

$$R''_{154}Al_{330}(Si_3O_8)_{300}(SiO_4)_{24}.$$

Again simplifying, this becomes

$$R''_{154}Al_{330}X_{324},$$

or very nearly 1:2:2, as in stilbite.

Similarly discussed, the ammonium salt gives the ratios

$$R'_{270}Ca_{46}Al_{352}Si_{1021}O_{2746},$$

equivalent to

$$R'_{362}Al_{352}X_{353}, \text{ or } 1:1:1.$$

In both cases the orthosilicate molecules are few, and the compounds approximate to trisilicates very closely.

CHABAZITE.

Characteristic flesh-colored crystals from Wassons Bluff, Nova Scotia. The analysis and fractional water determinations are—

SiO_2	50.78
Al_2O_3	17.18
Fe_2O_3	.40
MgO	.04
CaO	7.84
Na_2O	1.28
K_2O	.73
H_2O	21.85
	100.10

Fractional water.

At 100°	5.22
At 180°	5.70
At 250°	3.92
At 350°	2.36
Low redness	4.51
Full redness	.13
Over blast	.01
	21.85

The unignited mineral, upon boiling with sodium carbonate, gave 0.86 per cent of soluble silica. After ignition only 0.53 per cent was soluble. Here again no silica is liberated by calcination, and metasilicate formulæ may be disregarded.

Two samples of the ammonium chloride derivative were prepared, which after thorough washing were dried at 40° to 50°. As in the case of stilbite, small quantities of chlorine appear in the compound, not removable by washing. The amount of change effected is also somewhat less than with stilbite, and about the same as with heulandite. The analyses of the two samples are subjoined, with the remaining alkali all reckoned as soda:

	A.	B.
SiO_2	55.88	56.09
Al_2O_3	19.15	19.49
CaO	2.25	2.01
$Na_2O(K_2O)$	.35	.24
NH_3	4.64	4.83
H_2O	16.57	16.01
Cl	.95	1.35
	99.79	100.02
Less O	.21	.30
	99.58	99.72

In B, 1.50 per cent of soluble silica was found. After ignition this was reduced to 1.12 per cent. No liberation of silica accompanies the splitting off of water and ammonia.

Upon studying the molecular ratios for chabazite and its derivative, relations appear precisely like those found for stilbite and heulandite. For chabazite itself, rejecting water and the 0.86 per cent of soluble silica, we have

$$R'_{58}Ca_{141}Al_{340}Si_{832}O_{2344},$$

or, consolidating soda with lime,

$$Ca_{170}Al_{340}(Si_3O_8)_{246}(SiO_4)_{94}.$$

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One step further and this becomes

$$Ca_{170}Al_{340}X_{340}=1:2:2.$$

Treating derivative "B" in the same way, and ignoring chlorine as an unexplained impurity, the analysis gives

$$(NH_4)_{284}Na_8Ca_{35}Al_{382}(Si_3O_8)_{266}(SiO_4)_{112};$$

or, consolidating bases as before,

$$R'_{362}Al_{382}X_{378}=1:1:1 \text{ nearly.}$$

The assumption of commingled ortho- and trisilicate molecules conforms to Streng's theory of the constitution of chabazite.

THOMSONITE.

The compact-fibrous variety from Table Mountain, near Golden, Colo. Analytical data as follows:

SiO_2	41.13
Al_2O_3	29.58
CaO	11.25
Na_2O	5.31
H_2O	13.13
	100.40

Fractional water.

At 100°	1.01
At 180°	1.44
At 250°	1.05
At 350°	3.90
Low redness	5.65
Over blast	.08
	13.13

Before ignition the mineral yielded 0.45 per cent of silica to sodium carbonate solution. After ignition 0.68 per cent was soluble. The difference is trifling.

Two samples of the ammonium chloride derivative were prepared. In A the heating was only to 300°, in B to 350°. Analyses of the leached products gave the following results:

	A.	B.
SiO_2	42.41	42.65
Al_2O_3	30.50	31.34
CaO	10.00	9.23
Na_2O	2.63	2.48
NH_3	2.45	2.67
H_2O	11.96	11.81
	99.95	100.18

In A, 1.80 per cent of soluble silica was found.

In this case the amount of change is very much less than with the zeolites previously examined. Little lime was removed, and only about half of the soda. Both samples were prepared with six hours of heating in the sealed tube, and it seemed to be desirable to determine whether a more prolonged treatment would produce any greater effect. Accordingly a third lot of thomsonite was mixed with ammonium chloride and heated in a sealed tube to 350° for twenty-four hours. The leached product contained 3.40 per cent of ammonia, a distinct increase over the other findings, although the amount of transformation into an ammonium salt was still only moderate.

We have already seen that stilbite, heulandite, and chabazite approximate more or less nearly to trisilicates in their composition. Thomsonite, however, is essentially an orthosilicate, with variable admixtures of trisilicate molecules. In the example under consideration, ignoring water and soluble silica, the molecular ratios give this formula:

$$Na_{172}Ca_{201}Al_{580}(Si_3O_8)_{50}(SiO_4)_{528};$$

or, condensing,

$$R''_{287}Al_{580}X_{578}=1:2:2.$$

Here the acid radicles are ten-elevenths orthosilicate. Ammonium derivative A, similarly computed, gives first—

$$(NH_4)_{144}Na_{84}Ca_{178}Al_{598}(Si_3O_8)_{41}(SiO_4)_{554};$$

or, uniting univalent bases with lime,

$$R''_{292}Al_{598}X_{595}=1:2:2;$$

the fundamental ratios being practically unchanged.

It will be observed that in all of these computations of formulæ we have assumed that all the water is "zeolitic;" that is, independent of the true chemical molecules. This question, however, needs to be separately investigated for each individual species. While the assumption is valid for some of these minerals, it is not necessarily valid for all. The real chemical differences between the zeolites are yet to be determined; our work merely proves that ammonium compounds are formed, completely in some cases, partially in others. The research should be extended to cover all the zeolites; but this task we must leave to other investigators.

LAUMONTITE.

Upon this species only one rather crude experiment has been tried, and that upon material of unknown origin. The mineral was heated with ammonium chloride in a sealed tube as usual, and then leached with water. 4.51 per cent of lime and 0.35 of soda were extracted, and in the residue 3.95 per cent of ammonia was found. Laumontite, therefore, behaves much like the other zeolites, and is only partially transformed into an ammonium compound.

PECTOLITE.

The pectolite which was chosen for examination was the well-known radiated variety from Bergen Hill, N. J. The mineral was in long white needles, and apparently quite pure, but the analysis shows that it contained some carbonate as an impurity. Enough of the material was ground up to furnish a uniform sample for the entire series of experiments, and the work properly began with a complete analysis. The results obtained are as follows:

SiO_2	53.34
Al_2O_3	.33
CaO	33.23
MnO	.45
Na_2O	9.11
H_2O	2.97
CO_2	.67
	100.10

Fractional water.

At 105°	0.27
At 180°	.16
At 300°	.22
At redness	2.32
	2.97

All of the water was given off at a barely visible red heat, and the figures show that practically all of it is constitutional—a fact which perhaps hardly needed reverification. The analysis gives the accepted formula for pectolite,

$$HNaCa_2Si_3O_9.$$

Does this represent, as is commonly assumed, a true metasilicate? If it does, we should expect that ignition would split off silica proportional to the acid hydrogen, or one-sixth of the total amount. To answer this question several portions of the pectolite were sharply ignited, to complete dehydration, and then boiled each for fifteen minutes with a solution of sodium carbonate containing 250 grams to the liter. In the extract so obtained the silica was determined, and the three experiments gave the following percentages:

	8.96
	8.67
	8.42
Mean,	8.68

One-sixth of the total silica is 8.89 per cent, and the experiments, therefore, justify the original expectation. The belief that pectolite is a metasilicate is effectively confirmed.

Upon the unignited pectolite the sodium carbonate solution has a slow decomposing action, both silica and bases being withdrawn. In two experiments fifteen minutes of boiling extracted 2.07 and 2.55 per cent of silica, and by a treatment lasting four days 4.80 per cent

was taken out. With water alone similar results were obtained, the action being so rapid, although relatively slight, that pectolite, moistened, gives an immediate and deep coloration with phenol phthalein. By boiling the powdered pectolite with distilled water alone, 1.65 per cent of silica was brought into solution, and the ignited mineral, similarly treated for fifteen minutes, gave 1.78 per cent. The extraction in these cases is really an extraction of alkaline silicate, as the two following experiments prove. In A the unignited pectolite was boiled for fourteen hours with distilled water, and in B the mineral after ignition was subjected to like treatment for four hours. The dissolved matter in each case was determined, with the subjoined results:

Extracted.	A.	B.
SiO_2	2.98	3.03
CaO	.30	.10
Na_2O	.81	1.50
	4.09	4.63

In A no simple ratio appears, but in B the extracted silicate approximates very nearly to the salt $Na_2Si_2O_5$. In each instance the ratios vary widely from those of the original mineral, showing that actual decomposition and not a solution of the pectolite, as such, has occurred.

Schneider and Clarke,[a] in their first experiments upon the ammonium chloride reaction, treated pectolite from Bergen Hill three times successively with the reagent and then leached out with water. In the solution 20.50 per cent of lime and 6.95 of soda were found, showing that a very considerable decomposition had taken place, but the residue was not examined. In a preliminary experiment by the sealed tube method we found that 20.72 per cent of lime and 6.46 of soda were taken out, while 1.44 per cent of ammonia was retained by the residue. That is, two-thirds of the bases, approximately, had been converted into chlorides by the reaction. The open crucible and the sealed tube gave essentially the same results, although the retention of ammonia was not noticed by Schneider and Clarke.

In order to obtain further light upon pectolite we continued our experiments with the sealed tube method, and have obtained very variable results. All of the heatings with ammonium chloride were conducted at 350°, and the pectolite used was from the same Bergen Hill specimen which served us for our previous work. Our data are as follows, including for convenience of comparison the preliminary experiment which was cited above:

A. Heated six hours. On leaching, 20.72 per cent of lime, 6.46 soda, and 0.11 alumina dissolved. The residue contained 1.44 per cent of ammonia.

[a] Bull. U. S. Geol. Survey No. 113, p. 34, 1893.

B. Heated six hours. 20.10 per cent lime and 5.80 of soda extracted. 1.45 per cent ammonia in the residue. The residue was also examined for silica soluble in 25 per cent sodium carbonate solution (on fifteen minutes boiling), and 43.38 per cent was found.

C. Heated six hours. Soluble portion neglected. The residue contained 2.23 per cent of ammonia and 61.79 per cent of soluble silica. The full analysis of this residue is given later.

D. Heated ten hours. A complex breaking up of the pectolite took place, and leaching with water extracted the following percentages:

SiO_2	5.43
Al_2O_3	.22
CaO	28.20
MnO	.23
Na_2O	8.29

The residue from this leaching contained 39.63 of soluble silica, but ammonia was not determined.

These results are so irregular that definite conclusions can hardly be drawn from them. A and B agree fairly with each other, and also with the earlier work of Schneider and Clarke. C contains more ammonia, but differs widely from B as to the amount of soluble silica in the residue. D, which represents a long heating, indicates a more complete reaction than was observed in either of the other cases.

An ammonium compound, however, is evidently formed during the reaction, although its precise nature can not be determined from the evidence now in hand. Something may be inferred from the following figures, which are to be summarized thus: First, we reproduce from our earlier paper the analysis of the pectolite itself. Secondly, we give the analysis of the insoluble residue obtained in experiment C. The third column of figures is obtained by subtracting from the second column 61.79 of soluble silica and 1.18 of hygroscopic water, and recalculating the remainder to 100 per cent. The fourth column contains the molecular ratios calculated from the third.

	Pectolite.	Residue found.	Residue reduced.	Ratios.
SiO_2	53.34	75.98	37.74	0.629
Al_2O_3	.33	.08	.19	.002
CaO	33.23	9.56	25.43	.454
MnO	.45	.24	.63	.009
Na_2O	9.11	1.84	4.89	.079
NH_3	....	2.23	5.93	.349
H_2O at 100°	.27	1.18	....	....
H_2O above 100°	2.70	9.47	25.19	1.399
CO_2	.67	....	....	....
	100.10	100.58	100.00	....

These ratios roughly suggest the formation of a salt approximating in composition to the formula $R'_2Ca_2Si_3O_9.6H_2O$, in which R′ is about two-thirds ammonium and one-third sodium. The large amount of water found was doubtless absorbed during the process of leaching. Pectolite itself has the formula $NaHCa_2Si_3O_9$, so that the existence of a hydrous ammonium pectolite is indicated; a conclusion which is probable but not proved. The reaction between pectolite and ammonium chloride is possibly simple at first, but followed by or entangled with secondary changes which obscure the results. The experiments are interesting, however, as showing how widely pectolite differs from the other minerals which we have studied, as regards the ammonium chloride reaction.

WOLLASTONITE.

The only data relative to the action of ammonium chloride upon wollastonite are those given in the original paper by Schneider and Clarke, but on account of the close relationship between this species and pectolite it seems desirable to reproduce the record here. The mineral studied was from Diana. N. Y., and it had the subjoined composition:

SiO_2	50.05
Al_2O_3,Fe_2O_3	1.13
CaO	47.10
Na_2O	undet.
MgO	.09
H_2O	.45
	98.82

After two heatings with ammonium chloride in an open crucible, 36.98 per cent of lime became soluble in water. In other words, a very notable decomposition had occurred, as in the case of pectolite. Since wollastonite is an anhydrous mineral, this result shows that the reaction does not depend upon the presence of hydroxyl.

APOPHYLLITE.

Upon this species only one rather crude experiment was made, and that with material of unknown locality. Heated with ammonium chloride in a sealed tube, it gave up, on leaching with water, 21.59 per cent of lime and 5.18 of potassa. The residue contained only 0.79 per cent of ammonia. Evidently the mineral, like pectolite and wollastonite, is largely decomposed by the reagent; but it is uncertain whether any regular ammonium compound is formed. It must be remembered that apophyllite sometimes contains small quantities of ammonia, and hence it seems that a more complete investigation of it is desirable.

DATOLITE.

The compact, porcelain-like datolite from Lake Superior. This was heated in a sealed tube with ammonium chloride in the usual way. After leaching the product with water, the washed residue contained 91.09 per cent of silica and 1.17 of ammonia. Evidently the datolite molecule had been thoroughly broken down, with nearly complete removal of the bases and the boric acid. The significance of the retained ammonia, however, is not clear.

ELÆOLITE.

On account of their interest as rock-forming minerals, the three species nephelite var. elæolite, sodalite, and cancrinite were studied consecutively and with some reference to one another. The elæolite was the characteristic material from the elæolite-syenite of Litchfield, Me., and had the following composition:

SiO_2	45.91
Al_2O_3	31.14
Fe_2O_3	.34
FeO	.23
CaO	.33
Na_2O	14.60
K_2O	5.60
H_2O at 100°	.47
H_2O above 100°	.93
CO_2	.40
	99.95

Five grams of mineral were thoroughly mixed with 20 grams of ammonium chloride by long grinding in an agate mortar, and then heated for six hours in a sealed tube to 350°. Even during the grinding a strong smell of ammonia was noticeable, and upon opening the sealed tube after heating, a slight pressure of ammonia gas was observed. On extraction with water the following bases passed into solution:

$Fe_2O_3.Al_2O_3$	0.29
CaO	.07
Alkalies (calculated as soda)	2.10

The residue from the leach water was dried at 50°, and then found to contain 0.92 per cent of ammonia. These figures confirm those obtained in a much less careful preliminary experiment, and show that elæolite is but slightly affected by the reagent.

CANCRINITE.

The material studied was the well-known bright yellow cancrinite from Litchfield, Me., and an analysis of it gave the following results:

SiO_2	36.19
Al_2O_3	29.24
Fe_2O_3	trace
CaO	4.72
Na_2O	19.20
K_2O	.14
H_2O	4.15
CO_2	6.11
	99.75

Upon boiling the powdered mineral for fifteen minutes with the standard solution of sodium carbonate, 0.55 per cent of silica went into solution. After ignition, only 0.32 per cent was soluble. No silica, therefore, had been split off by heating.

With ammonium chloride two experiments were made. In each case the mineral was intimately ground with four times its weight of the chloride, and heated to 350° in a sealed tube for four hours. During grinding a strong smell of ammonia was noticed, and still more was given off when the tubes were opened. The products were leached with water, and the thoroughly washed residues were analyzed, as follows:

	A.	B.
SiO_2	37.48	37.51
Al_2O_3	31.23	31.98
CaO	5.10	5.30
$Na_2O(+K_2O)$	7.78	7.53
NH_3	4.73	3.77
H_2O at 100°	1.29	14.48
H_2O above 100°	12.24	
CO_2	none	none
	99.85	100.57

In the wash water from product B, 11.73 per cent of the original soda was found, with no lime, and 0.16 per cent of silica and alumina. Somewhat less than two-thirds of the soda had been taken out. The lime seems to be much more stably combined, and water was taken up, probably in the process of leaching. The carbonic acid of the cancrinite had been completely eliminated.

Apparently, if the product of the reaction is a definite compound, the effect of the ammonium chloride has been to transform the cancrinite into a zeolitic body, approximating roughly to the general formula

$$R^1Al\ SiO_4.\ H_2O,$$

but with a small excess of the univalent bases. Analysis A, adjusted by rejecting the 1.29 per cent of hygroscopic water, and recalculation of the remainder to 100 per cent, assumes the following form and gives the appended ratios:

	Analysis reduced.	Ratios.
SiO_2	38.03	0.634
Al_2O_3	31.69	.311
CaO	5.17	.093
Na_2O	7.89	.127
NH_3	4.80	.282
H_2O	12.42	.690
	100.00	....

The substance is evidently not absolutely pure, a condition which might have been expected. Any closer attempt at precise formulation would therefore be useless. It most nearly resembles, among the products which we have obtained, the ammonium derivative of thomsonite.

SODALITE.

Dark-blue sodalite from Kicking Horse Pass, British Columbia. Analysis as follows:

SiO_2	39.66
Al_2O_3	30.09
Fe_2O_3	.31
CaO	.18
Na_2O	22.60
K_2O	1.14
H_2O at 100°	.17
H_2O above 100°	.79
Cl	6.12
	101.06
Less O=Cl	1.39
	99.67

With ammonium chloride two preparations were made, both by the sealed-tube method at 350°. In A the heating lasted twenty-four hours; and in B six hours. From residue A, by leaching with water, 2.96 per cent of alkali, reckoned as soda, was extracted; and from B,

3.53 per cent. In the washed residues the following determinations were made, but complete analysis seemed to be unnecessary.

	A.	B.
SiO_2	39.33	40.00
$Al_2O_3(Fe_2O_3)$	31.40	32.34
CaO	.20	....
$Na_2O(K_2O)$	20.86	....
NH_3	.45	.72
Cl	5.92	....

Evidently the amount of change was slight, and no definite ammonium derivative had been formed.

In one way these results shed some light upon the constitution of sodalite. According to Lemberg and his pupils the mineral is a double salt, a molecular compound of sodium chloride with a silicate like nepheline. If this view were correct sodium and chlorine should be removed together by the action of a decomposing reagent. We find, however, that about 3 per cent of soda was removed from sodalite in forming residue A, while practically all of the chlorine remains behind. So far, then, the evidence is adverse to the view just cited and favorable to that of Brögger, which assigns the mineral, as an atomic compound, to a place in the garnet group.

On the other hand, sodium chloride may be volatilized from sodalite by prolonged heating. Two portions of the mineral were each heated for four hours over a blast-lamp flame, losing 10.80 and 10.72 per cent, respectively. The chlorine in the mineral, 6.12 per cent, corresponds to 10.08 per cent of NaCl; to this must be added the 0.91 of water found, making a total possible loss of 11.04 per cent. In the residue from the first lot ignited 0.20 of chlorine was found, so that the volatilization of sodium chloride had been almost complete. This reaction, however, taking place at a very high temperature, may be only a result of metathesis, and not by any means a proof that sodium chloride, as such, is an essential constituent of sodalite. The evidence derived from the ammonium chloride reaction is entitled to the greater weight.

THE FELDSPARS.

The results which we have obtained with these important rock-forming minerals are interesting only in so far as they show a trifling sensitiveness on the part of the several species toward dissociating ammonium chloride. The action upon them is slight, and ammonium derivatives do not seem to be formed. The data may be briefly summarized as follows:

Orthoclase.—From southeastern Pennsylvania, exact locality unknown. Quite pure cleavage masses. Heated for six hours with

ammonium chloride to 350° in a sealed tube, and leached with water, 1.52 per cent of KCl went into solution. The residue, dried at 50°, contained 0.20 per cent of ammonia.

Oligoclase.—The transparent variety from Bakersville, N. C. Treated like the orthoclase. In the leach water 0.96 per cent of lime and 2.71 of soda were found. The air-dried residue contained 1.47 per cent of ammonia. It is barely possible that in this case an ammonium derivative may have been produced, but the data are not positive enough to warrant any definite conclusion.

Albite.—Well-crystallized and very pure material from Amelia Courthouse, Va. Treated like the two preceding feldspars. Upon leaching, 0.12 per cent of lime and 0.84 of soda went into solution. In the residue, dried at 50°, 0.32 per cent of ammonia was retained.

OLIVINE.

Green, transparent pebbles from near Fort Wingate, N. Mex. Examined by Schneider and Clarke, who employed only the open crucible method. By treatment with ammonium chloride only 0.44 per cent of magnesia was rendered soluble in water—i. e., converted into magnesium chloride. In view of the ready solubility of this mineral in even weak aqueous acids, this lack of sensitiveness to ammonium chloride is somewhat remarkable.

ILVAITE.

This rare mineral was found by Mr. Waldemar Lindgren at the Golconda mine, South Mountain, Owyhee County, Idaho. It occurs in jet black masses and occasional rough crystals, embedded in quartz or calcite, and intimately associated with two other minerals which appear to be garnet and tremolite. Traces of pyrite also appear. The specific gravity of the ilvaite, as determined by Dr. Hillebrand, is 4.059 at 31°.

Upon grinding the powdered mineral with ammonium chloride in an agate mortar, a distinct smell of ammonia was noticeable. Three tubes of the mixture were heated to 350°, and one exploded because of the liberation of gas within. Upon opening the second and third tubes, a strong outrush of ammonia was observed. When the contents of these tubes were leached with water, large quantities of ferrous chloride went into solution, which, rapidly oxidizing, formed a deposit of brownish hydroxide, and interfered seriously with filtration. The greater part of the lime in the ilvaite was dissolved also. The washed residue, containing much ferric hydroxide, was partially analyzed, and enough data were obtained to show that a general breaking down of the ilvaite molecule had been effected. Apparently, also, small quantities of an ammonium derivative had been formed;

but this point is uncertain. The original mineral was analyzed by Dr. W. F. Hillebrand, and his analysis, contrasted with that of the leached residue, is here given:

	Ilvaite (Hillebrand).	Residue (Steiger).
SiO_2	29.16	43.01
Al_2O_3	.52	40.08
Fe_2O_3	20.40	
FeO	29.14	8.75
MnO	5.15	.85
CaO	13.02	2.25
MgO	.15	undet.
Na_2O	.08	undet.
NH_3	....	.88
H_2O at 105°	.15	undet.
H_2O above 105°	2.64	undet.
Cl	....	([a])
	100.41	95.82

[a] Small amount.

In the leached residue from the third tube 21.37 per cent of soluble silica was found—silica which had been liberated during the reaction between the ilvaite and the ammonium chloride. In short, ilvaite behaves toward the reagent much like pectolite, and the product is a mixture of uncertain character. The evident instability of the ilvaite molecule may account for its rarity as a mineral species. Only exceptional conditions would favor its formation.

RIEBECKITE(?).

The results obtained with ilvaite made it desirable to study, for comparison, some other silicates of iron. Among these the mineral from St. Peters Dome, near Pikes Peak, Colorado, originally described by Koenig as arfvedsonite, but identified by Lacroix as near riebeckite, happened to be available. It was treated with ammonium chloride in the usual way and no presence of liberated gas was noticed when the tube was opened. On leaching the product with water, ferrous chloride went into solution and ferric hydroxide with some manganic hydroxide was deposited. In the leached mass 6.90 per cent of soluble silica was found, and in the wash water from the leaching there was 6.76 per cent of soda. According to Koenig's analysis the mineral contains 8.33 per cent of soda, so that a large portion of the total amount had been extracted. There was also,

evidently, a considerable breaking down of the molecule, but no definite ammonium derivative had been formed. This is shown by the following analysis of the leached residue, which is contrasted with Koenig's published analysis[a] of the original mineral in order to indicate the amount of change. In the third column of figures we give the amount of each constituent which could be dissolved out from the residue by treatment with hydrochloric acid.

	Riebeckite (Koenig).	Residue (Steiger).	Soluble portion.
SiO_2	49.83	67.54	
TiO_2	1.48		
ZrO_2	.75		
Fe_2O_3	14.87	21.28	15.74
FeO	18.86	4.94	4.94
MnO	1.75	.64	.64
MgO	.41	none	
CaO		trace	
Na_2O	8.33	1.04	
K_2O	1.44		
NH_3		.53	.53
H_2O	.20	3.33	
Cl		trace	
	97.87	99.30	

The residue is evidently a mixture of free silica and ferric hydrate with probably at least two silicates, one soluble, the other insoluble in hydrochloric acid. The reaction itself is noteworthy because of the fact that the original mineral is but slightly attacked when boiled with strong hydrochloric acid. The other minerals so far studied by us are all easily decomposable by acids, while this one is quite refractory. The energetic character of the ammonium chloride reaction is thus strongly emphasized.

ÆGIRITE.

Material from the well-known locality at Magnet Cove, Arkansas. Not absolutely pure, but somewhat contaminated by ferric hydroxide. This impurity is evident in a discussion of the ratios furnished by the analysis, but is not serious. It does not affect the problems under consideration. By heating with ammonium chloride the mineral was only slightly changed. In the leach water from the product there

[a] Dana's System of Mineralogy, 6th ed., p. 400.

were 1.66 per cent $(AlFe)_2O_3$, 0.51 CaO and 1.18 Na_2O. Analyses as follows: A of the ægirite, B of the air-dried, leached residue.

	A.	B.
SiO_2	50.45	51.83
Al_2O_3	2.76	25.24
Fe_2O_3	23.42	
FeO	5.26	5.69
MnO	.10	....
MgO	1.48	1.58
CaO	5.92	5.74
Na_2O	9.84	9.07
K_2O	.24	
NH_3	....	.26
H_2O at 100°	.15	.90
H_2O above 100°	.40	
	100.02	100.31

Of the silica in the residue 4.42 per cent was soluble in sodium carbonate solution. An ammonium derivative was not formed.

From these data we see that the three iron silicates are very differently attacked by ammonium chloride; ilvaite very strongly, riebeckite moderately, and ægirite but feebly. The ægirite is the most stable and at the same time the commonest of the three. A comparison of the ægirite analysis with that made by J. Lawrence Smith of material from the same region shows notable differences. The mineral evidently varies in composition, the variation depending upon the relative amounts of the two silicate molecules $FeNaSi_2O_6$ and $R''SiO_3$. Two samples taken from different parts of the same rock area are not necessarily identical in composition.

CALAMINE.

The simplest constitutional formula for calamine, the one which is generally accepted, represents it as a basic metasilicate,

$$SiO_3{=}(ZnOH)_2.$$

In this the hydrogen is all combined in one way, and so, too, is the zinc. In all other possible formulæ, simple or complex, the hydrogen as well as the zinc must be represented as present in at least two modes of combination; a condition of which, if it exists, some evidence should be attainable. Our experiments upon calamine have had this point in view; and we have sought to ascertain whether water or zinc could be split off in separately recognizable fractions. Our results, in the main, have been negative, and tend toward the support of the

usual formula; but the data are not conclusive, although they seem to be worthy of record.

The beautiful white calamine from Franklin, N. J., was selected for study, and gave the subjoined composition:

SiO_2	24.15
Al_2O_3, Fe_2O_3	.19
ZnO	67.55
CaO	.12
H_2O	7.95
	99.96

Fractional water.

At 100°	0.27
At 180°	.22
At 250°	.75
At 300°	.88
Incipient red heat	4.46
Full red heat	1.37
	7.95

Here no clear and definite fractionation of the water is recognizable, at least of such a character as to suggest any other than the ordinary formula for calamine.

Upon boiling powdered calamine with water, practically nothing went into solution, but by boiling with the solution of sodium carbonate 0.25 per cent of silica was dissolved. After ignition at a red heat, only 0.14 per cent of silica became soluble in sodium carbonate; and after blasting, only 0.24. In these experiments a very little zinc was dissolved also; but there was no evidence that any breaking up of the mineral into distinguishable fractions had occurred. In a hot 10 per cent solution of caustic soda both the fresh and the ignited calamine dissolve almost completely; but boiling with aqueous ammonia seems to leave the mineral practically unattacked. All experiments aiming to extract a definite fraction of zinc while leaving a similar fraction behind resulted negatively.

By heating with dry ammonium chloride in an open crucible, calamine is vigorously attacked and gains in weight by absorption of chlorine. In two experiments the mineral was intimately mixed with three times its weight of powdered sal ammoniac and heated in an air bath for several hours to a temperature somewhat over 400°. A large part of the residue was soluble in water, and the percentage of this portion, together with the percentage increase in weight, is given below:

	I.	II.
Gain in weight	27.60	25.78
Soluble in water	53.23	67.13

A conversion of calamine into the chlorhydrin $SiO_3(ZnCl)_2$ would involve a gain in weight of 15.34 per cent. Complete conversion into $2ZnCl_2+SiO_2$ implies an increase of 38.14 per cent. The figures given lie between these two, and are indefinite also for the reason that there was volatilization of zinc chloride.

In two more experiments the calamine, mingled with three times and four times its weight of ammonium chloride, respectively, was heated for an hour and a half to bright redness in a combustion tube. The zinc chloride which was formed volatilized and was collected by suitable means for determination. It corresponded to 59.6 and 59.0 per cent of the original mineral, calculated as zinc oxide, which indicates a nearly complete decomposition of the calamine into $2ZnCl_2+SiO_2$. The residue was mainly silica, with a small part of the zinc, about half of the silica being soluble in sodium carbonate solution. Here again no definite fractionation of the mineral could be observed.

Finally the action of dry hydrogen sulphide upon calamine was investigated. The mineral was heated to redness in a current of the gas and gained perceptibly in weight. The percentage data, reckoned on the original calamine, were as follows, in two experiments:

	I.	II.
Gain in weight	6.00	6.43
SiO_2 soluble in Na_2CO_3	16.45	20.95
Sulphur in residue		24.12

Complete conversion of calamine into $2ZnS+SiO_2$ implies a gain in weight of 5.80 per cent, and it is therefore evident from the figures of the second experiment that the limit of change was approached very nearly. The 24.12 of sulphur taken up is quite close to the 26.53 per cent which is required by theory. About eight-ninths of the calamine had undergone transformation. Again no definite fractionation was detected.

The hydrogen sulphide reaction was examined still further with reference to the temperature at which it becomes effective. Even in the cold calamine is slightly attacked by the gas, but its action is unimportant until the temperature of 400° is approximated. Then it becomes vigorous and the reaction goes on rapidly. A few experiments with willemite showed that it also was attacked by hydrogen sulphide, but less vigorously than calamine.

PYROPHYLLITE.

The empirical formula for pyrophyllite, $AlHSi_2O_6$, is apparently that of an acid metasilicate, and the mineral is therefore peculiarly available for fractional analysis. The compact variety from Deep

River, N. C., was taken for examination, and a uniform sample was prepared. Analysis gave the following results:

SiO_2	64.73
TiO_2	.73
Al_2O_3	29.16
Fe_2O_3	.49
MgO	trace
Ignition	5.35
	100.46

If, now, pyrophyllite is an acid metasilicate it should break up on ignition in accordance with the equation

$$2AlHSi_2O_6=Al_2Si_3O_9+SiO_2+H_2O.$$

That is, one-fourth of the silica, or 16.18 per cent, should be liberated. The mineral itself is very slightly attacked by boiling with the sodium carbonate solution, and in an experiment of this kind only 0.72 per cent of silica was dissolved. Upon ignition under varying circumstances the following data were obtained:

Ignited ten minutes over a Bunsen burner, and then extracted with sodium carbonate solution, 1.51 per cent of SiO_2 dissolved.

Ignited fifteen minutes over a Bunsen burner, 1.89 per cent became soluble.

Ignited ten minutes over a Bunsen burner and then fifteen minutes over the blast, 2.84 per cent of silica was liberated.

These results are of a different order from those given by pectolite and talc, and raise the question whether pyrophyllite, despite its ratios, is a metasilicate at all. So far as the evidence goes, it may with propriety be regarded as a basic salt of the acid $H_2Si_2O_5$, and its formula then becomes

$$Si_2O_5=Al-OH.$$

This formula is at least as probable as the metasilicate expression, which latter rests upon assumption alone. Still other formulæ, but of greater complexity, are possible; but until we know more of the genesis and chemical relationships of pyrophyllite, speculation concerning them would be unprofitable.

By heating with ammonium chloride in an open crucible pyrophyllite is very slightly attacked. In two experiments it lost in weight 6.17 and 6.30 per cent, respectively. The excess of loss over water is due, as we have proved, to the volatilization of a little ferric and aluminic chloride. The residue of the mineral after this treatment contained no chlorine, so that no chlorhydrin-like body had been formed. The formation of such a compound, the replacement of hydroxyl by chlorine, would, if it could be effected, be a valuable datum toward determining the actual constitution of the species. The sealed tube experiments were not attempted.

SERPENTINE.

In 1891 Clarke and Schneider published an investigation[a] relative to the action of gaseous hydrochloric acid upon various minerals. Among these were the three species, serpentine, leuchtenbergite, and phlogopite, and the remainders of the original samples were fortunately at our disposal. The analyses made by Schneider are therefore directly comparable with the new data secured by us.

The serpentine, from Newburyport, Mass., was but moderately attacked upon heating with ammonium chloride. Upon leaching the contents of the sealed tube with water, 0.18 per cent of silica and 5.23 of magnesia went into solution. The washed residue and the serpentine had the following composition:

	Serpentine (Schneider).	Residue (Steiger).
SiO_2	41.47	45.42
Fe_2O_3, Al_2O_3	1.73	.88
MgO	41.70	39.54
FeO	.09	....
NH_3	....	.09
H_2O	15.06	14.01
	100.05	99.94

The leached residue contained 1.06 per cent of soluble silica. The amount of change effected in the mineral was evidently small, and no ammonium compound was produced.

In Schneider and Clarke's[b] paper upon the ammonium chloride reaction a serpentine from the river Poldnewaja, district of Syssert, in the Urals, was studied. By a single treatment in an open crucible 4.93 per cent of magnesia became soluble in water as chloride. In a second experiment the mineral, after heating with 10 grams of ammonium chloride until volatilization ceased, was reheated with 10 grams more. Upon leaching, 14.30 per cent of magnesia went into solution. In a third trial the serpentine was thrice treated and only 10.63 per cent of magnesia was converted into chloride. In the last case the residue was boiled with sodium carbonate solution, which extracted 3.82 per cent of silica. The same serpentine was completely decomposable by aqueous hydrochloric acid, but only moderately attacked by the dry gas. The evident irregularity of these results is yet unexplained.

PHLOGOPITE.

From Burgess, Canada. The contents of the sealed tube, after heating, showed little appearance of change. The leach water contained magnesia. Analyses as follows:

[a] Bull. U. S. Geol. Survey No. 78, p. 11, 1891. [b] Bull. U. S. Geol. Survey No. 113, p. 34, 1893.

	Phlogopite (Schneider).	Residue (Steiger).
SiO_2	39.66	45.03
TiO_2	.56	....
Al_2O_3	17.00	15.07
Fe_2O_3	.27	
FeO	.20	....
BaO	.62	....
MgO	26.49	24.94
Na_2O	.60	.94
K_2O	9.97	8.69
NH_3	....	.21
H_2O	2.99	5.01
F	2.24	....
	100.60	99.89
Less O	.94	
	99.66	

The residue, on boiling with sodium carbonate, gave 0.40 per cent of soluble silica. From these data it appears that phlogopite is somewhat attacked by ammonium chloride, but not strongly. No definite ammonium derivative is formed.

LEUCHTENBERGITE.

From the standard locality near Slatoust, in the Urals. When the contents of the sealed tube were leached with water, there passed into solution 0.19 per cent of alumina, plus iron, 2.10 of magnesia, and 2.03 of lime. The residue was not completely analyzed, but the few determinations made contrast with Schneider's results as follows:

	Leuchtenbergite.	Residue (Steiger).
SiO_2	32.27	32.82
Al_2O_3	16.05	....
Fe_2O_3	4.26	....
FeO	.28	....
MgO	29.75	....
CaO	6.21	4.67
NH_3	....	.25
H_2O	11.47	12.11
	100.29	....

No definite ammonium compound was formed, and the amount of decomposition was small. As the lime shown by the analysis is at least partly due to the presence of garnet as an impurity in the mineral, it will be interesting to determine the effect producible by ammonium chloride upon that species.

In Schneider and Clarke's investigation, conducted in open crucibles, this same leuchtenbergite, after three heatings with ammonium chloride, gave up 3.98 per cent of magnesia upon leaching with water. The residue contained a little magnesium oxychloride. With clinochlore from Slatoust similar results were obtained. A double heating with ammonium chloride extracted 2.12 per cent of magnesia, and a triple heating took out 3.80 per cent.

XANTHOPHYLLITE.

Variety waluewite, from the Nikolai-Maximilian mine, district of Slatoust, Urals. Examined by Schneider and Clarke, who found the mineral to be practically unattacked by gaseous hydrochloric acid, but completely decomposable by the aqueous acid. A triple treating with ammonium chloride in an open crucible took out 0.48 per cent of lime and 0.61 of magnesia. This amount of decomposition is insignificant.

THE ACTION OF AMMONIUM CHLORIDE ON ROCKS.

From the evidence so far presented it is clear that the ammonium-chloride reaction has much theoretical interest and that it adds a good deal to our knowledge of chemical constitution. But does it go any further than this and render any assistance in the elucidation of other problems? Consider, for instance, the rational analysis of silicate rocks—that is, the quantitative determination of certain mineral constituents as distinguished from the ordinary estimation of the oxides—is the reaction of any service here? We have found that among the rock-forming minerals analcite and leucite are completely transformable into ammonium salts, while elæolite and the feldspars are but little affected; olivine and the ferro-magnesian silicates also react but slightly. It would seem, therefore, as if analcite and leucite might be approximately determined by means of the reaction, the amount of change produced in a rock mixture being some measure of their quantity. To test this supposition, we have made a number of experiments, using for the purpose well-known rocks which had been studied both mineralogically and chemically.

Our method of procedure has been extremely simple, and no refinements of process have as yet been attempted. Each rock, in fine powder, was mixed with four times its weight of ammonium chloride and heated for several hours in a sealed tube to 350°. After cooling, the mixture was leached with water, and the amount of alkali passing into solution was estimated. From this soluble alkali the amount of analcite or leucite in the rock may be be roughly inferred, but of

course not with any great degree of accuracy. Still an approximate estimation is better than no measurement at all and is of service to the petrographer. Fortunately the errors of the process are to some extent compensatory; a little analcite or leucite will always escape transformation, while on the other hand a little alkali will always be yielded by other species. One error renders the estimation of the alkali too low, the other makes it high, but the two tend to balance each other. In the ordinary process for separating soluble from insoluble silicates by means of aqueous hydrochloric or very dilute nitric acid the same errors occur, but with additional complications due to the solution of magnesian minerals like olivine. Furthermore, aqueous acids will not discriminate between analcite and nepheline, two species which behave very differently toward dissociating ammonium chloride. So much premised, we may pass on to the description of our experiments.

First, we examined three rocks from the Leucite Hills, Wyoming, which were analyzed by Hillebrand and described by Cross.[a] Their mineralogical composition is as follows:

A. Orendite. Contains predominating leucite and sanidine, with phlogopite, a little biotite, diopside, and amphibole, and accessory apatite and rutile.

B. Wyomingite. Contains phlogopite, leucite, diopside, and apatite.

C. Madupite. Contains predominating diopside and phlogopite, with perofskite and magnetite, in a glassy base, which has approximately the composition of leucite.

On A and B duplicate determinations were made, but only one in the case of C. The substances extracted by leaching, after treatment with ammonium chloride, are given below:

	A 1.	A 2.	B 1.	B 2.	C.
Al_2O_3, Fe_2O_3	0.26	0.21	0.64	0.64	0.21
CaO	1.28	1.48	1.67	1.70	5.06
K_2O	4.68	4.53	9.50	9.38	6.81
Na_2O	.25	.43	1.33	1.35	1.08

The duplicates are fairly concordant. If now we regard the K_2O thus extracted as a measure of the leucite in each rock, giving the mineral its normal composition $KAlSi_2O_6$, we have the following percentages of the latter:

In orendite:
- 1 .... 21.81
- 2 .... 21.11

In wyomingite:
- 1 .... 44.47
- 2 .... 43.71

In madupite 31.73

[a] Am. Jour. Sci., 4th series, Vol. IV, p. 115. See also Bull. U. S. Geol. Survey No. 168, pp. 85 and 86, 1900, for analyses.

Two other leucite rocks were also studied by us, as follows, both being given in duplicate:

D. Missourite, Highwood Mountains, Montana. Described by Weed and Pirsson.[a] Analyzed by E. B. Hurlbut. Contains augite and leucite, with apatite, iron oxides, olivine, and biotite. Some zeolites and analcite are also present.

E. Leucitite, Bearpaw Mountains, Montana. Described by Weed and Pirsson.[b] Analyzed by H. N. Stokes. An olivine-free leucite basalt. Contains leucite, augite, iron oxides, rarely biotite, and a very small amount of glassy base.

The following substances were taken out by the ammonium chloride reaction:

	D 1.	D 2.	E 1.	E 2.
CaO	1.73	1.70	0.89	1.29
K_2O	4.09	3.74	6.19	6.16
Na_2O	.59	.64	1.44	1.47

Hence we have for leucite—

In missourite .... 19.06 and 17.43
In leucitite .... 28.84 and 28.70

It will be observed that the extracted soda is neglected in the computation. In missourite it may represent analcite; in the other rocks it perhaps belongs to a sodium equivalent of leucite, or it may come from some still different source. At all events, it serves to indicate some of the uncertainties attending the application of the method.

Among the rocks containing analcite as an essential constituent, only two were available for our purposes. They are:

F. Analcite-basalt, from Basin, Colorado. Described by Cross.[c] Analyzed by Hillebrand. Contains phenocrysts of augite, olivine, and analcite; also magnetite, and minor amounts of alkali feldspars, biotite, and apatite.

G. Heronite, from Heron Bay, Lake Superior. Described by Coleman.[d] Contains analcite, orthoclase, labradorite, ægirite, limonite, and calcite.

By treatment with ammonium chloride the following bases were extracted from these rocks, determinations being made in duplicate:

	F 1.	F 2.	G 1.	G 2.
CaO	1.74	2.28	1.64	1.62
K_2O	.46	.49	.21	.18
Na_2O	3.42	3.29	6.04	6.37

[a] Am. Jour. Sci., 4th series, Vol. II, p. 315; Bull. U. S. Geol. Survey No. 168, p. 133.
[b] Am. Jour. Sci., 4th series, Vol. II, p. 143; Bull. U. S. Geol. Survey No. 168, p. 136.
[c] See Bull. U. S. Geol. Survey No. 168, p. 146.
[d] Jour. Geology, Vol. VII, p. 431.

Hence, reckoning the soda as equivalent to normal analcite, $NaAlSi_2O_6.H_2O$, we have as percentages of the latter:

In analcite-basalt .... 26.33 and 25.33
In heronite .... 46.51 and 49.05

According to Coleman's computations, heronite contains 47 per cent of analcite. This figure agrees quite perfectly with our experimental determination.

In order to gain some notion of the extent to which other rocks, containing neither analcite nor leucite, might be affected by the reaction with ammonium chloride, four examples were chosen from among the many which have been studied in this laboratory.[a] They were:

H. Phonolite, Uvalde County, Tex. Contains sanidine, nepheline, and ægirite, with very little brown hornblende, augite, and magnetite.

I. Soda-granite-porphyry, Merced River, Mariposa County, Cal. Contains feldspar, largely albite, hornblende, muscovite, epidote, apatite, and iron ore.

J. Granitite, Placerville Canal, Eldorado County, Cal. Contains biotite, orthoclase, plagioclase, and quartz.

K. Augite-latite, Table Mountain, Tuolumne County, Cal. Contains labradorite, olivine, augite, and magnetite.

The bases extracted from these four rocks were as follows, in percentages:

	H.	I.	J.	K.
Al_2O_3, Fe_2O_3	0.33	0.19	0.58	....
CaO	.22	.29	none	0.66
K_2O	.41	.20	.20	1.21
Na_2O	4.38	.33	.23	.66

Among these rocks only the first one, the phonolite, was seriously affected; and it is difficult to account for the large amount of soda extracted. Neither nepheline nor ægirite taken alone gives up nearly so much soda as was liberated in this case, and no other sodium mineral has been reported present in the rock. In the other cases the amount of extraction is small and amounts to no more than the plus error, which was pointed out at the beginning of this discussion.

Taking all things into account, it seems probable that the analytical method proposed, although far from exact, is capable of some development, and is likely to yield results of some value. Perhaps it might be improved by taking into account the quantities of ammonia retained by the washed residues. From that source one estimate could be derived, and from the alkali in solution another; the two should give better information than either determination alone. But the precision of ordinary analytical processes is not to be expected here, and only useful approximations can be anticipated.

[a] For additional data and the analyses, see Bull. U. S. Geol. Survey No. 168, pp. 62, 199, 205, 217.

SUMMARY.

In the foregoing pages we have considered the action of ammonium chloride, at its temperature of dissociation, upon 31 mineral species. We have shown that its influence upon various silicates differs very widely, but that in general it is a much more powerful reagent than has been generally supposed. The results, in brief, are as follows:

First. Analcite, leucite, natrolite, and scolecite, heated with dry ammonium chloride to 350° in a sealed tube, yield alkaline chlorides and an ammonium aluminum silicate, which is stable at 300°. The reaction is simply one of double decomposition, the sodium or potassium of the original silicate being completely replaced by ammonium. Analcite and leucite give the same product, $NH_4AlSi_2O_6$. Natrolite and scolecite yield the salt $(NH_4)_2Al_2Si_3O_{10}$. The latter compound is a derivative of orthotrisilicic acid, $H_8Si_3O_{10}$; and in a separate section of the memoir its constitution and its relations to other trisilicic acids are considered.

Second. A similar reaction, a double decomposition, takes place incompletely with stilbite, heulandite, chabazite, thomsonite, laumontite, and pollucite. Part of the monoxide base is removed and replaced by ammonium, without change of atomic ratios. Cancrinite is also vigorously attacked, and partially transformed into a zeolitic body.

Third. Pectolite, wollastonite, apophyllite, datolite, ilvaite, and calamine are violently acted upon by ammonium chloride, and their molecules seem to be almost completely broken down. The products of the reactions are mixtures, and no ammonium silicates are formed.

Fourth. Elæolite, sodalite, riebeckite, olivine, serpentine, phlogopite, prehnite, orthoclase, albite, oligoclase, ægirite, pyrophyllite, leuchtenbergite, and xanthophyllite are but slightly attacked by dissociating ammonium chloride.

In the closing section of the work we have shown that the ammonium chloride reaction may be applied to an approximate quantitative determination of analcite and leucite in rocks, thereby aiding somewhat in the estimation of their mineralogical composition.

O

PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Bulletin No. 207.]

The serial publications of the United States Geological Survey consist of (1) Annual Reports, (2) Monographs, (3) Professional Papers, (4) Bulletins, (5) Mineral Resources, (6) Water-Supply and Irrigation Papers, (7) Topographic Atlas of United States—folios and separate sheets thereof, (8) Geologic Atlas of United States—folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists may be had on application.

The Bulletins, Professional Papers, and Water-Supply Papers treat of a variety of subjects, and the total number issued is large. They have therefore been classified into the following series: A, Economic geology; B, Descriptive geology; C, Systematic geology and paleontology; D, Petrography and mineralogy; E, Chemistry and physics; F, Geography; G, Miscellaneous; H, Forestry; I, Irrigation; J, Water storage; K, Pumping water; L, Quality of water; M, Methods of hydrographic investigation; N, Water power; O, Underground waters; P, Hydrographic progress reports. This bulletin is the thirty-sixth in Series E, the complete list of which follows (all are bulletins thus far):

SERIES E, CHEMISTRY AND PHYSICS.

9. Report of work done in the Washington laboratory during the fiscal year 1883-84, by F. W. Clarke and T. M. Chatard. 1884. 40 pp.

14. Electrical and magnetic properties of the iron carburets, by Carl Barus and Vincent Strouhal. 1885. 238 pp.

27. Report of work done in the Division of Chemistry and Physics, mainly during the year 1884-85. 1886. 80 pp.

32. Lists and analyses of the mineral springs of the United States (a preliminary study), by Albert C. Peale. 1886. 235 pp.

35. Physical properties of the iron carburets, by Carl Barus and Vincent Strouhal. 1886. 62 pp.

36. Subsidence of fine solid particles in liquids, by Carl Barus. 1886. 58 pp.

42. Report of work done in the Division of Chemistry and Physics, mainly during the fiscal year 1885-86, by F. W. Clarke. 1887. 152 pp., 1 pl.

47. Analyses of waters of the Yellowstone National Park, with an account of the methods of analyses employed, by Frank Austin Gooch and James Edward Whitfield. 1888. 84 pp.

52. Subaerial decay of rocks and origin of the red color of certain formations, by Israel Cook Russell. 1889. 65 pp., 5 pls.

54. On the thermoelectric measurement of high temperatures, by Carl Barus. 1889. 313 pp., 11 pls.

55. Report of work done in the Division of Chemistry and Physics, mainly during the fiscal year 1886-87, by Frank Wigglesworth Clarke. 1889. 96 pp.

60. Report of work done in the Division of Chemistry and Physics, mainly during the fiscal year 1887-88. 1890. 174 pp.

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